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Massachusetts. Charles River Dam Com.

Commonwealth of Massachusetts.

EVIDENCE AND ARGUMENTS

BEFORE THE

COMMITTEE

ON

CHARLES RIVER DAM

APPOINTED UNDER

RESOLVES OF 1901, CHAPTER 105.

DECEMBER 16, 1901, TO JANUARY, 1903.

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COMMITTEE ON CHARLES RIVER DAM.

FIRST HEARING.

BOSTON, MASS., Dec. 16, 1901.

The special committee appointed by the Governor to consider and report upon a plan for damming Charles River met in Room 240, State House extension, at 10 A.M., for the purpose of giving a public hearing, notice of this hearing having been given by advertisement in the Boston "Globe," Boston "Herald," Boston "Advertiser," Boston "Transcript," Cambridge "Chronicle," Cambridge "Tribune" and Watertown "Enterprise."

All the members of the committee — Henry S. Pritchett, Esq. (chairman), Col. Samuel M. Mansfield and Richard H. Dana, Esq. — were present.

The CHAIRMAN. I will ask, gentlemen, in opening these proceedings, that the secretary of the commission read chapter 105 of the Resolves of 1901, under which the commission is to act: —

RESOLVE TO PROVIDE FOR THE APPOINTMENT OF A COMMITTEE TO CONSIDER THE ADVISABILITY OF CONSTRUCTING A DAM ACROSS THE CHARLES RIVER, BETWEEN THE CITIES OF BOSTON AND CAMBRIDGE.

Resolved, That the governor, with the advice and consent of the council, be authorized and requested to appoint, not later than the thirty-first day of December, nineteen hundred and one, a committee, to consist of three or more suitable persons, one of whom he shall designate as chairman, to investigate and report upon the feasibility and desirability of constructing and maintaining a dam across Charles river between Boston and Cambridge, in the vicinity of the bridges known as Craigie's bridge and West Boston bridge. The committee may employ such assistance as may be necessary, shall give a hearing to all persons desiring to be heard upon the subject, and shall make a report of their doings, with such recommendations as they may deem proper, to the next General Court. The committee may expend such sums in the performance of its duties and shall be allowed such compensation, as the governor and council may determine. The whole expense of the committee shall be borne equally by the cities of Boston and Cambridge. The powers of the committee shall terminate on the making of their report. If the committee concludes that the proposed

dam is feasible and desirable, they shall recommend a plan for apportioning the expense of constructing and maintaining it, between such cities and towns as will specially be benefited by it, and they shall annex to their report the draft of a bill in accordance with their recommendations. The provisions of this resolve shall be accepted by a majority vote of the city councils of Boston and Cambridge before any action can be taken thereunder. [*Approved June 13, 1901.*

The CHAIRMAN. Under the provisions of that resolve the Governor has appointed a committee, and that committee is now before you. I may say briefly, in beginning this conference, that the committee, after some consultation, has thought it wise to proceed in some such way as this. It is desired by the committee to hear the opinions and statements of all parties for and against the project, as they may desire to be heard; but, at the same time, the committee will be glad if it is not found necessary to repeat here again and again reports and testimony already in print. The printed reports of investigations already had on this subject and the testimony already given upon it are accessible to the committee, and such testimony as has been given by or before various commissions contains much that probably might be said here; and it is hoped by the committee that some time may be saved by inserting such reports as have already appeared in print, and which contain evidence which parties desire to bring forward. It is also the desire of the committee at its next sitting to ask, first of all, that certain evidence be placed before it from existing Boards, such as plans, or proposed improvements, on the part of the Park Commission, or the Water and Sewerage Commission, or the United States engineers. The committee will desire to have knowledge of the plans which the Park Commissioners have in view, and will endeavor to ascertain the plans of the Metropolitan Water and Sewerage Commission, and to learn what the plan of the army engineers may be in regard to the whole project; and, having these plans before it, this committee will be glad to hear, first, from those who favor the proposed project of constructing a dam across the Charles River; and then the committee will be glad to hear, secondly, from those who may desire to be heard in opposition to the proposed project. After these parties have been heard from, the committee will then summon such experts as they may consider it wise to hear.

The following gentlemen entered their appearance before the committee: W. S. Slocum, city solicitor for the city

of Newton; Hon. Nathan Matthews, Jr., for James J. Storrow and other gentlemen interested in the furtherance of the projected dam; Hon. James R. Dunbar and Wm. D. Turner, for a committee consisting of Chas. Head, L. S. Dabney and Howard Stockton, representing the residents along the water front of Beacon Street and property owners in opposition to the project of constructing a dam across the Charles River; Hon. A. E. Pillsbury, representing the interests of the owners on the Cambridge shore of the river, between the Craigie bridge and West Boston bridge; Hon. Gilbert A. A. Pevey, city solicitor for the city of Cambridge; Chas. S. Hamlin, Esq., representing the Boston Chamber of Commerce; Clinton White, as chairman of a committee of the Boston Associated Board of Trade; A. H. Brooks, Esq., for the Cambridge Electric Light Company; Frederic D. Fisk, for the trustees of the Main Street Land Trust; A. J. Bailey, Esq., corporation counsel for the city of Boston; William B. de las Casas, Esq., chairman of the Metropolitan Park Commission; F. W. Webber, on behalf of the Faneuil Improvement Society of Watertown; J. Richard Carter, president of the Boston Associated Board of Trade; Woodward Emery, Esq., chairman of the Harbor and Land Commission; John C. Cobb, for the Boston Merchants' Association; E. B. Bishop, for the estate of Horace Cousens and John E. Cousens, lessee; Dr. Henry J. Barnes, for Tufts College Medical School; Warren and Garfield, for the Butchers' Slaughtering and Melting Association.

The chairman of the Harbor and Land Commission offered to supply this committee with any data in the possession of his commission.

The committee then adjourned until Monday, Jan. 13, 1902, at 10 A.M.

SECOND HEARING.

STATE HOUSE, BOSTON, Jan. 13, 1902.

The second public hearing of the special committee on the Charles River dam was held in Room 240, State House extension, at 10 A.M. to-day.

Present: the chairman and commissioners, Col. Samuel M. Mansfield and Richard H. Dana.

The CHAIRMAN. The committee has asked to appear before us this morning not only such gentlemen as may be interested either in one way or the other in the construction of a dam across the Charles River, to inquire into the feasibility of such construction, but we have also requested the larger engineering departments of the cities of Boston and Cambridge and of the neighboring cities and towns to be present at the hearing this morning, and to present such information as they may have, and which ought to be taken into account by this commission and others, in the consideration of such a proposition. We shall ask those representatives of the Metropolitan Sewerage Board, the State Board of Health, the Harbor and Land Commission and other bodies who may be present to present such data as they may have available to show what facts or what plans they have in their departments, and how their work would be affected by such an enterprise. In doing so, I wish to explain to these gentlemen themselves that the committee does not at this moment ask them for their opinions as to the feasibility of such a dam across the Charles River, because such a problem and such answer would probably be impossible at the present time, without any definite plan before us to discuss; but we desire to have such information before us as would enable us to know whether any plan at all would be feasible, and, if so, what kind of a plan would affect the operation of those great engineering departments. Most of these gentlemen have been kind enough to send in to this committee written reports, giving the present state of the work in their various departments, as well as outlines of the plans which they have in contemplation. Any further verbal explanations which they may care to give us at this time would be quite helpful.

The following report was then read, from Mr. Guy C. Emerson, acting superintendent of streets of Boston: —

BOSTON, MASS., Jan. 7, 1902.

Mr. J. W. LUND, *Secretary Committee on Charles River Dam, Room 203, 14 Beacon Street, Boston.*

DEAR SIR: — Your notification of January 4 of the hearings to take place before your committee at the State House received, and I send you herewith plans which have been prepared in accordance with the request contained in your letter of Dec. 20, 1901. As no information is given in that letter regarding the plans of your committee, I presume that none were available. I have therefore been unable to discuss in any way the engineering difficulties which might arise from the construction of the dam, or to formulate any plans on behalf of the department for obviating such difficulties.

So far as anticipated at the present time, the only interest of the department is to see that the various outlets for natural water courses entering the proposed basin — several of which are used for overflows for the various combined systems of sewerage within their water-sheds — are adequately maintained. The principal of these water courses are the new Stony Brook channel, which now enters the Fens Pond at the corner of Parker Street and Huntington Avenue, and the extension of which is contemplated in the near future to the Charles River; the old Stony Brook channel, which has an overflow entering the Fens Pond at the same place, but which is at present carried to the Charles River by a wooden conduit, which it will be necessary to rebuild in the near future. The entire channel in Rogers Avenue and other streets between the Fens Pond and Roxbury Crossing is in very bad condition, and will have to be rebuilt in the near future. The supplementary outlet for Muddy River in Brookline Avenue between the parkway and the Charles River will have to be rebuilt in the near future. There are also smaller brooks, such as the Salt Creek Brook, the Shepard Valley Brook and the Faneuil Valley Brook, for which conduits entering the Charles River have already been constructed, or are projected for construction in the near future.

On the plans which are submitted herewith, and which are intended to be self-explanatory, I have endeavored to indicate the actual existing conditions, showing by suitable colorings the various drainage areas, with the correct sewerage system for each area, whether combined or separate. I have also indicated the boundaries between the different areas sewered and between the various water-sheds tributary to the different natural water courses. I have also shown the location of the various outlets through which the overflow from the combined systems enters the Charles River, but it is to be understood that there are also overflows into the various natural water courses, such as Stony Brook, which are not indicated on this plan, it being assumed by me that some precaution would be taken to carry the foul flow of these water courses below the location of the proposed dam.

The conditions in many of these water courses will no doubt be very much improved from the present by the operation of the metropolitan high-level sewer, which will take care of a large portion of the high-level sewage in the Stony Brook valley, thus diverting it from the present Stony Brook channel.

Very respectfully,

GUY C. EMERSON,
Acting Superintendent of Streets.

Mr. EMERSON then appeared and said: As acting superintendent of streets of the city of Boston, I have issued a certain report, which, although hastily prepared, indicated the only conditions in which the city of Boston was interested at the present time, and that was in regard to the natural water courses of the city of Boston. There are the Stony Brook, which enters into the old Fens Pond channel; the old channel, which also enters into the Fens; the conduit which is now in Brookline Avenue, and into which only a portion of the sewerage enters; and besides these a few smaller ones in Brighton, — Salt Creek, South Valley Brook and the so-called Shepard Valley Brook; the plans prepared, and the one you see before you, simply show the conditions which either myself or Mr. Dore will be glad to explain to you.

The CHAIRMAN. That plan shows the drainage area, I believe?

Mr. EMERSON. Yes; the plans are indexed, and show the line of demarcation between the water-sheds and the positions of the various overflows in the Charles River.

Mr. EMERSON. We have endeavored to show, by different markings and colorings on the plan, the conditions which exist in the different areas. This is a plan of Jan. 6, 1892. That is, the areas shown in brown are sewerage on the combined system, which includes storm water and house sewage. The portions marked in the blue are those which are sewered under the separate systems. This heavy, dotted black line shows the divide between, or shows rather the outline between Stony Brook and Muddy River drainage area, that is, shows the Charles River line; and the smaller line shows the Muddy River divide. These very small dotted lines show the various subdivisions. The Boston main drainage system is shown by the red lines, the metropolitan sewerage system is shown by the heavy dotted red lines; that is, the Charles River system, which is at present tributary to the Boston main drainage system; that is, the heavy red dotted line. The heavy blue line shows that portion of Stony Brook which has been already developed by building a closed conduit for it, and the small remaining blue line beyond the end of the heavy line shows the various branches of Stony Brook which will have to be developed by conduits in the future.

Mr. CHARLES S. HAMLIN. May I ask if that is a sewer there, — Stony Brook, there, from that up?

Mr. EMERSON. It takes only surface water at the present time.

Mr. HAMLIN. Where does the surface water enter in?

Mr. EMERSON. It takes nearly the entire surface drainage water from this water-shed south of the end of the closed channel, and also by means of catch-basins all along the closed channel.

Mr. HAMLIN. It doesn't begin where it is covered over, necessarily?

Mr. EMERSON. The green line shows the old channel of Stony Brook, which will have to be rebuilt in the future. The brown line in Brookline Avenue shows the present Muddy River conduit, so called, which takes a portion of the foul flow of Muddy River, the remaining portion finding its way through Fens Pond to the Charles River. This blue area shows Jamaica Pond with its outlet, which is Muddy River.

The CHAIRMAN. Does that carry anything more than overflow?

Mr. EMERSON. Several overflows, from several combined systems. At present I think the Boston system has no overflow into Muddy River. The foul flow from the old channel of Stony Brook it does not take.

Commissioner DANA. May I ask what you mean by the foul flow?

Mr. EMERSON. Dry weather flow usually. The blue shows the area containing sewers on the separate systems; that is, it has both house sewers and storm water sewers.

Mr. HAMLIN. I should like to ask him about the old channel of Stony Brook, whether there is any house sewer entering there through Jamaica Plain sewer so that it connects into the Back Bay basin?

Mr. EMERSON. I think there is. I should say there was undoubtedly considerable sewage which found its way into that channel, — not directly from the sewer, but from the premises along the banks.

Mr. HAMLIN. The question I wanted to ask was, whether any sewer actually discharged into the old channel.

Mr. EMERSON. I think there is none.

The CHAIRMAN. In regard to the brown area there on the plans to which you refer in your report, do your plans contemplate any other disposition of storm water than that which is now had? That is, is that brown district likely to become at any time all blue?

Mr. EMERSON. No, I think not. We are separating the systems as fast as possible. Of course Cambridge I know nothing about. Undoubtedly Brighton will be sewered in the separate system at not a very far distant date. Perhaps

the entire area except Boston proper will be on the separate system.

The CHAIRMAN. Indicate again, please, what you mean by the separate system.

Mr. EMERSON. There are two sewerage systems, one for the storm water and another for the house drainage.

The CHAIRMAN. Do you think it likely that most of that brown area will become within three or four years what you have indicated by blue?

Mr. EMERSON. I should not say that it would become so within three or four years, but perhaps within ten or fifteen years it may.

The CHAIRMAN. It will be put on what you call the separate system?

Mr. EMERSON. Yes.

The CHAIRMAN. And the written reports which go with your written reply to the letter of the committee contain what facts you have given here?

Mr. EMERSON. Yes.

Commissioner DANA. Which is preferable, the combined system or the separate system, for the health of a district of this kind under the present circumstances?

Mr. EMERSON. I should say the separate system was preferable under any circumstances.

Commissioner DANA. And, independently of any question of a dam, ought, in your opinion, this separate system to be introduced?

Mr. EMERSON. Yes, sir; I think that is a matter which should be done as soon as it is possible to do so, without regard to the question of the construction of a dam or any other consideration. I believe they ought to be separated; that the separate system is preferable under any circumstances.

Commissioner DANA. Then let me ask you a further question. What will be the effect of the high-level sewer which is now being constructed? Does your department have anything to do with that?

Mr. EMERSON. No, except that the high-level sewer will take the drainage of the large portion of the high-level territory, Roxbury and Dorchester, which is now tributary to the system of Boston, and using the combined system, and will therefore take the sewage of this section from the system of the city of Boston and divert it to the high-level system. We have a plan here, and it shows it. It goes out through Quincy and through Hyde Park.

Commissioner DANA. May I ask what board has special charge of that subject?

Mr. EMERSON. The Metropolitan Water and Sewerage Commission.

Commissioner DANA. In the combined system, the street water, for example, goes first into the catch-basin, does it not?

Mr. EMERSON. Yes, sir.

Commissioner DANA. And then goes into a sewer which combines house sewage with the street drainage?

Mr. EMERSON. Yes, sir.

Commissioner DANA. And when a conductor, for example, leads from the roof or gutter down to the drainage system in Boston, it connects, in the combined system, with a drain which has house sewage in it?

Mr. EMERSON. Very frequently, yes.

Commissioner DANA. Well, if it connects with any sewer, it must connect with that, doesn't it?

Mr. EMERSON. Yes, if it connects with any sewer, it must connect with that.

Commissioner DANA. Into the sewer?

Mr. EMERSON. Yes.

Commissioner DANA. Is there any practical danger in that, not in regard to dwelling houses especially, but in general?

Mr. EMERSON. No.

Commissioner DANA. I will ask you this, if a conductor leads, as it sometimes does, from a Mansard roof, near a window, and connects with the main drainage system, in dry weather isn't there danger that the trap may be dried out, and so sewer gas come up under the windows?

Mr. EMERSON. I presume that that would be more a plumbing question than an engineering question, and I should presume that the thing might happen.

Commissioner DANA. Now, I want to ask about this, whether there are any sections in the city of Boston that use the combined system where there is a trouble, if a storm occurs during a very high tide, in the way of backing up and filling the cellars or yards.

Mr. EMERSON. Yes, there are several; not only that, but there are several in the higher portions of the city where trouble occurs without regard to the tides.

Commissioner DANA. Without regard to the tides?

Mr. EMERSON. Yes.

Commissioner DANA. In those places I suppose it occurs because the sewers are not large enough; is that it?

Mr. EMERSON. Practically, yes; that is the case because the sewers are not large enough; yes.

Commissioner DANA. In the lower portions of the city has there been complaint of that state of affairs occurring lately?

Mr. EMERSON. There are always complaints. Whenever we have a heavy storm, we have a large number of complaints following.

Commissioner DANA. When this does come up into the house, this that backs up, it is the combined house sewage and storm drainage?

Mr. EMERSON. Usually; yes.

Commissioner DANA. I suppose that is one of the reasons why you wish to get rid of the combined system, isn't it?

Mr. EMERSON. Yes, sir; that is one of the improvements we expect from the metropolitan system, — the improvement which will come from the amount which they will take out from our system.

Commissioner DANA. You do not have in mind at present how much they propose to take out from your system?

Mr. EMERSON. I do not have it in mind at present; perhaps Mr. Dore does.

Commissioner DANA. Perhaps he will tell us. Let me ask you this other question. A good many of these sewers as they at present exist in the Back Bay district in the combined system are not tight; isn't that so, — or are they all tight sewers?

Mr. EMERSON. Well, that is a very difficult question to answer, — whether they are perfectly tight. I presume none of them would be considered perfectly tight if the ground was taken away from them. I think they are all in pretty good condition. We try to keep the system in pretty good condition. If there are any defective sewers found, we rebuild them as soon as possible.

Commissioner DANA. Those that have been open have been found to be tight, have they?

Mr. EMERSON. I cannot say that we have had any great trouble with sewers in the Back Bay district recently, since my connection with the office.

Commissioner DANA. Well, as to those sewers that are covered up, are they always supposed to be tight, or are they supposed to be loose-jointed?

Mr. EMERSON. House connections?

Commissioner DANA. Yes.

Mr. EMERSON. They are supposed to be tight.

Commissioner DANA. Have you ever investigated the question as to whether when there is this storm water back-

ing up, any of those sewers leak into the ground under the houses?

Mr. EMERSON. I have investigated a good many cases of floodings at times of high tide.

Commissioner DANA. That is, they flooded into the back yards and cellars?

Mr. EMERSON. Yes; in some of the back yards on Beacon Street we find it occasionally, and neighboring streets.

Commissioner DANA. Not only those that have direct openings from Beacon Street, but those that run into the combined system on Clarendon Street and places in that neighborhood?

Mr. EMERSON. Yes, sir; what street did you mention?

Commissioner DANA. I said Clarendon Street, but that runs also to the water. I meant Marlborough Street and streets beyond there.

Mr. EMERSON. Yes.

Mr. HAMLIN. One thing I wanted to ask Mr. Emerson, to state the number of overflow connections between existing sewers which empty into tributaries which finally find their way into the Charles River Basin, taking the entire water-shed, as far as he can answer that question.

Mr. EMERSON. I have no idea, at the present time; it would require considerable investigation to look the matter up.

Mr. HAMLIN. Of course in all those various overflows there may be tributaries emptying into the Charles River, and if Mr. Emerson would take the time to ascertain that, it would be of great value.

The following report from Mr. Henry H. Sprague, the chairman of the Metropolitan Water and Sewerage Board, was then read to the committee: —

BOSTON, Jan. 7, 1902.

President HENRY S. PRITCHETT, *Chairman*.

DEAR SIR: — I send you, in response to your request of Dec. 16, 1901, a statement regarding the systems of sewerage on the sides of Charles River, as they seem to affect the matter of your investigation.

The Metropolitan Water and Sewerage Board controls systems of main drainage, shown in outline on a map submitted herewith, and serving two areas, north and south of the Charles River, known as the north and south metropolitan sewerage districts.

North Metropolitan District.

The sewage of the north metropolitan district is concentrated into a trunk sewer with an outlet at Deer Island, in Boston harbor, about

4½ miles below the city proper. A branch of this sewer passes through the city of Somerville, and thence through a considerable part of the city of Cambridge. At its upper end, in Mount Auburn Street, at Lowell Street, it is about 2 feet in diameter and about 5 feet above mean low water. It follows a course approximately parallel to the river, and is gradually enlarged until, at the Somerville city line, opposite the proposed location of a dam in the Charles River, near Craigie's bridge, its diameter is about 5½ feet and its invert is about 8 feet below mean low water. Its total length in Cambridge is about 4 miles.

This sewer provides for the drainage of approximately nine-tenths of the population of Cambridge, or for about 85,000 persons using the sewer. The sewers of the city are practically all connected with the metropolitan system. They admit rainfall as well as sewage, being largely on what is known as the "combined" system. Works have, however, been constructed in some parts of the city for diverting the greater part of the storm water into separate channels, communicating directly with the river, leaving only the domestic sewage and manufacturing wastes, with some rainfall, to enter the metropolitan sewer. The metropolitan sewer is designed to deal only with flows of this limited volume, and the connections of the city sewers with the metropolitan sewer are, therefore, controlled by automatic valves, which close in time of storm and allow the combined sewage and rainfall to pass through the former outlets into the Charles River, instead of into the metropolitan sewer. It has been established, by observations of the city engineering department, that the aggregate duration of this shutting off of the sewers is about 600 hours per annum, equal to about 7 per cent. of the whole period. There are no direct overflows from the metropolitan sewer into the river. With a dam holding the Charles permanently at an elevation of 8 feet above mean low water, it will be necessary, after each shut-off on account of storms, to pump out the water stored in the city sewers below grade 8. The permanent retention of water in the Charles River at grade 8 would probably have the further effect of increasing the leakage into the sewerage systems, owing to the increased external pressure on the metropolitan and city sewers.

South Metropolitan District.

The south metropolitan sewerage system, in the Charles River valley, consists of about 8 miles of trunk sewer, following generally the course of the river on its southerly side, and providing for the drainage of Waltham and Watertown north of the river, and in part for Newton, Brighton, Brookline and the Back Bay district of Boston on the south. The population contributing sewage is approximately 85,000. The upper three towns, Waltham, Watertown and Newton, are sewered on the separate system, providing only for the admission of domestic sewage, manufacturing wastes and a very limited volume of storm water. The sewerage works of the remaining areas, Brighton, Brookline and the included portion of the Back Bay district, are largely on the "combined" system, as in Cambridge. Automatic valves, as described for that city, are generally used on the connections throughout the system. There are also two direct overflows from the metropolitan sewer into the river; one of these, about 4 feet in diameter, is in St. Mary's Street, and discharges through the trunk sewer of the town of Brookline; the other, about the same size, discharges through the Parsons Brook sewer belonging to the city of Boston.

Under an agreement between the Commonwealth and the city of Boston, the metropolitan sewer in the Charles River valley discharges

into the sea, until the high-level sewer is completed, through the Boston main drainage system. The Charles River valley sewer commences at the Waltham-Newton line, with a diameter of 3½ feet and an elevation of about 21 feet above mean low water. At the intersection of Huntington Avenue and Gainsborough Street in Boston, where it now connects with the Boston system, it is 6½ feet in diameter and 5 feet below mean low water. The Boston main drainage works are considerably used for the disposal of rainfall, especially in providing storm water relief for the Back Bay and other low districts. As at present operated, there is considerably more shut-off, during storms, on the south side of the Charles River than on the north.

For the necessary relief of this and other metropolitan sewers in the south metropolitan district, this Board is constructing a high-level gravity sewer, the main line of which is to extend, for the present, from Perkins Street, in Jamaica Plain, to a new harbor outfall about one mile north of Nut Island, in Quincy. This main line will ultimately be extended in a north-westerly direction through Brookline and Brighton to the Newton line, with the object of intercepting the sewage from the upper levels of the Charles River by gravity, and correspondingly relieving the existing metropolitan sewer in that valley. A branch of the high-level sewer is now in process of construction from Perkins Street to a proposed pumping station at the corner of Ward and Vancouver streets, near the Back Bay district. The sewage of the Charles River valley sewer will be pumped into this branch, and other parts of the south metropolitan district will drain into the high-level sewer by gravity.

The total length of the new high-level sewer, from the existing Charles River valley sewer to the outlet, will exceed 16 miles. Of this length, 6 miles are completed, 7 miles are under construction, and the remaining portions are in readiness for the letting of contracts during the coming season. The completion of the high-level sewer as far as now authorized is expected in about two years from the present time.

With this relief effected, it may be anticipated that the period during which the south metropolitan sewers will be shut off for overflow into the Charles River will not materially vary from that now observed in Cambridge, and that a permanent water surface at grade 8 in the Charles River might involve, as on the Cambridge side, additional pumping.

Yours very truly, HENRY H. SPRAGUE,
Chairman.

The CHAIRMAN. Is there anything further in the way of verbal information which Mr. Brown, engineer of sewerage works of Metropolitan Water and Sewerage Board, can give?

Mr. BROWN. Nothing that I care to at the present time.

Commissioner DANA. I should like to ask one question of Mr. Brown. That report speaks of 600 hours of overflow on the north metropolitan —

Mr. BROWN. That is, north of the Charles River.

Commissioner DANA. Was that based on the clocks of the Cambridge city engineer?

Mr. BROWN. Yes, sir.

Commissioner DANA. You did not see his last report, this year, did you?

Mr. BROWN. I had his last report, within a week or two.

Commissioner DANA. The last printed report?

Mr. BROWN. Yes, sir.

Commissioner DANA. But the last report that he is preparing, I mean?

Mr. BROWN. That is the average overflow of one of his large connections for three years.

Commissioner DANA. Hasn't there been an additional pump put in in that north metropolitan district since the time those hours you refer to were taken?

Mr. BROWN. I think that tally covers a year from the time the additional pump was put in.

Commissioner DANA. When was that pump put in operation?

Mr. BROWN. It has been in operation more than a year.

Commissioner DANA. The last printed report did not contain that. Which printed report did you take that from?

Mr. BROWN. I didn't take that information from a printed report, but from a verbal report which the city engineer of Cambridge gave me.

Commissioner DANA. And your statement was based upon that, I suppose?

Mr. BROWN. Yes, sir; my statement was based upon that.

Commissioner DANA. And I understand there is a still later report that comes within that period, and that there is a diminution; I think it comes down to about 400 hours.

Mr. BROWN. I think it will be more than 700 hours; but the average, I understand, is from 500 to 600 hours.

Commissioner DANA. This extra pump was started about 1901?

Mr. BROWN. I couldn't state the exact date when it was started, but about fifteen months ago.

Mr. MATTHEWS (recalling Mr. Emerson). Mr. Emerson, does any of the water of Stony Brook flow into the improved sewerage system of Boston, which is operated in connection with the improved metropolitan system?

Mr. EMERSON. I have no knowledge of any.

Mr. MATTHEWS. Well, let me ask you, first, whether you are sufficiently familiar with the operation of the sewerage system of Boston, both the improved system and the metropolitan system and the local system, to answer any questions that may be put to you?

Mr. EMERSON. I should say that I was; yes, sir.

Mr. MATTHEWS. Can you tell me, then, whether any waters are diverted, then, at any time?

Mr. BAILEY. Mr. Emerson has had charge of the sewerage system during the last two years.

Mr. MATTHEWS. Whether the improved system of the city of Boston, operating in connection with the metropolitan sewerage system, takes care of Stony Brook?

Mr. EMERSON. I don't know that it does.

Mr. MATTHEWS. Do you know whether it does or does not?

Mr. EMERSON. I do not know that it does; I think it does not.

Mr. MATTHEWS. State whether there is any connection, and how it is operated. One crosses the other, doesn't it?

Mr. EMERSON. Yes.

Mr. MATTHEWS. Now, is there any connection at that point?

Mr. EMERSON. There are several connections between Stony Brook and the sewers which are tributary to the system. As I have stated in my letter, which I hardly dignified as a report, they operate as overflows. Whether they ever operate backwards, or not, I do not know; I think not; I have never known them to do so.

Mr. MATTHEWS. Are there any connections between the new improved sewerage built in 1886 and the new main sewer of the improved system of the city of Boston?

Mr. EMERSON. I can only reiterate what I said before; that there are overflows into Stony Brook, and that constitutes a connection between the various sewers.

Mr. MATTHEWS. Let me call your attention to the connection at Huntington Avenue. I will ask you whether there isn't any connection at that point?

Mr. EMERSON. There is in that neighborhood. The plan is on too small a scale to indicate the exact point.

Mr. MATTHEWS. That is the fact? Is there any connection, and, if so, where?

Mr. EMERSON. There is, as a matter of fact, an overflow connection.

Mr. MATTHEWS. So that the waters of Stony Brook could be diverted into the metropolitan system?

Mr. EMERSON. No, I think not, unless very abnormal conditions obtained.

Mr. MATTHEWS. None, physical or mechanical?

Mr. EMERSON. I have not the recollection of the grade of the two conduits at that time, so I could not answer that question.

Mr. MATTHEWS. Then I will ask you to look at the plans and report to the committee whether practical connections could be made or are made between the metropolitan sewer system, so that some portion, if not the whole, of Stony Brook could be diverted into the system, if required.

Mr. EMERSON. I can say now that it would be impossible to divert all or a small portion of it into the metropolitan sewer system, on account of the small size of the sewers.

Mr. MATTHEWS. What is the size of the improved sewerage system at that point where Stony Brook connects?

Mr. EMERSON. Five feet, I think.

Mr. MATTHEWS. Have you got that data?

Mr. EMERSON. I have not now with me.

Mr. MATTHEWS. When you say that it is important that the water courses should be maintained, what do you mean?

Mr. EMERSON. In the same condition.

Mr. MATTHEWS. I notice you used the expression "foul overflow," and you told the chairman you meant the ordinary dry weather overflow.

Mr. EMERSON. In that case.

Mr. MATTHEWS. As you use it in your report, in what sense do you use it?

Mr. EMERSON. In the connection in which it is written, whether the foul overflow results from dry weather or other causes, refuse from manufactures which might take place, or what. I mean exactly foul flow, depending on exactly the location where it occurs.

Mr. MATTHEWS. In your answer to the chairman this morning, you said you meant dry weather flow from the start.

Mr. EMERSON. If I remember it right, the gentleman asked me about a particular case, — that is, overflow from the old channel of Stony Brook.

Mr. MATTHEWS. That old channel is not used at all now, is it?

Mr. EMERSON. Yes, that is used.

Mr. MATTHEWS. How is that used now?

Mr. EMERSON. It is used as a storm water drain.

Mr. MATTHEWS. Will you explain what you mean by "storm water," as distinct from foul?

Mr. EMERSON. By the term "storm water drain," I mean that it is used as an outlet for catch-basins.

Mr. MATTHEWS. Would that old channel carry off the ordinary overflow as well as foul overflow?

Mr. EMERSON. The old channel would, down to its outlet at Fenway Pond.

Mr. MATTHEWS. Why do you speak of the foul flow of Stony Brook in particular? What do you mean by that, as to the quality?

Mr. EMERSON. The old channel is in bad condition, and in moderate storms, on account of street washings and things of that sort, the water which flows into the old channel is of course more or less foul. The overflow conduit into the Charles River takes the flow from ordinary storms. In the more violent storms of course the overflow is not sufficient, and it goes into Fenway Pond.

Mr. MATTHEWS. Have you got at your office any model or any diagram which would show the operation of the catch-basin in the sewer system, so as to indicate the extent to which rain water would find its way to the sewers and cause overflow?

Mr. EMERSON. I think we have very complete records. I know we have very complete records of the city of Boston sewers, and also from catch-basins.

Mr. MATTHEWS. At the next hearing I should be obliged to you if you would produce such models or diagrams as would show that, or in regard to the Back Bay.

Mr. EMERSON. The Back Bay system is a combined system.

Mr. MATTHEWS. Exactly; I want some models or diagrams to indicate all of that.

Mr. EMERSON. You mean diagrams to show connection with the sewer?

Mr. MATTHEWS. Yes, and the operation of it; a diagram to show it if it be a fact that in time of storms the overflows do take place. I do not mean the plotted diagrams, I mean the typical sketch, showing how the combined system works on that part of the system. I thought perhaps you had it; if not, whether it would be possible to make one.

Mr. EMERSON. Yes.

Report of Alexis H. French, town engineer of the town of Brookline, was then read, as follows: —

BROOKLINE, MASS., Jan. 6, 1902.

DR. HENRY S. PRITCHETT, *Chairman, Committee on Charles River Dam.*

DEAR SIR: — In response to your letter of December 16 ult., I respectfully submit the following statement, together with the accompanying map, on which are shown the location, size and elevation of such

sewers and surface water drains and the surface level of such streets and low lands as are likely to be affected by the proposed dam.

The main sewer, which was originally a tidal sewer discharging into the Charles River opposite St. Mary's Street, was designed by J. Herbert Shedd, and was built by him in 1877, six years prior to the completion of the Boston main drainage system. The sewer is 7 feet in diameter at the Harbor Commissioners' line, and at that point has an invert elevation of —7 and in Commonwealth Avenue of 1.90, the datum being Boston city base. The slope of the sewer is 1 foot in 2,000 from Commonwealth Avenue to Brook Street.

The drainage areas in and contiguous to Brookline are so situated topographically that parts of Brookline drain through outlets owned by the city of Boston, while at other points considerable areas in Boston and Newton drain into the Brookline system. The following table shows approximately the areas in each municipality which either now drain, or will probably ultimately drain, through the Brookline main sewer: —

MUNICIPALITY.	Area drainable on the Combined System (Acres).	Area drainable on the Separate System (Acres).	Total Areas (Acres).
Newton, . . .	–	203	203
Boston,. . . .	205	96	301
Brookline, . . .	700	2,055	2,755
Totals, . . .	905	2,354	3,259

The Brookline main sewer continued to discharge into Charles River until April 29, 1892, when its 24 inch connection with the metropolitan system at the junction of Commonwealth Avenue and St. Mary's Street was put in operation. This connection is controlled by the usual automatic regulator.

The metropolitan sewer passes beneath the Brookline sewer at the point of crossing in Commonwealth Avenue. When the former sewer was built, the Metropolitan Commission placed a tide gate in the Brookline sewer near their junction, and built a 4 foot channel connecting the two systems, so that the old Brookline outlet serves as an overflow for both.

In case the proposed dam is built, the Brookline system will have to overflow against the constant elevation to which the river is raised, rather than against the present varying elevation. Subsequent to each use of the overflow, the accumulated storm water and sewage, from the permanent grade of the river to that of the bottom of so much of the Brookline system as lies below that level, will be discharged into the metropolitan sewer and be pumped by that department. This volume will be about 1,250,000 gallons, if the river is held at grade 8.

As the drainage system is now arranged, the only area in which the water level will be permanently raised by the building of the proposed dam is one lying between Beacon Street and Commonwealth Avenue, and west of Essex Street. It is about 25 acres in extent, its centre is about 1,500 feet from Charles River; and, as the outlet is now built, the ground water can be held at elevation of 7 or 8. The elevation after the proposed dam is built would depend upon the height of the dam.

The normal elevation of the water in Muddy River parkway is 11, with the bottom at grade 3. With the present outlet into Charles

River, the water can be drawn down so that the removal of deposits about the mouths of the brook channels is a comparatively simple matter. The holding the river at any elevation which is likely to be adopted for the purpose of a dam will add materially to the cost of doing such work.

There is no work planned or now in progress which will be affected by building the proposed dam.

Very respectfully,
ALEXIS H. FRENCH,
Town Engineer.

A. H. FRENCH. The statement as read, it was thought, contained all the information that is needed at the present time, but if more is required it will be furnished.

Commissioner DANA. Are there any sewers built on the separate system, or are they all on the combined system?

Mr. FRENCH. So far as the town is drained at all, there are about 700 acres in the districts which are sewered on the combined system, and about 2,055 acres in those that are drained on the separate system.

Commissioner DANA. I notice you said here "drainable on the combined or separate system." Do you mean now?

Mr. FRENCH. At the present time there are comparatively large undrained areas in districts which have been drained on either one or the other of the two systems. When sewers are called for in these areas, the natural method would be to extend into them the system of the character of the one of the district in which they are located. In the table presented the areas have therefore been classified as "drainable" on that theory, on one system or the other.

Commissioner DANA. Now, I want to get this clear. What do you mean by "drainable on the combined system," — that there are some additional areas which you will have to connect with the combined sewers, or what?

Mr. FRENCH. Merely that there are, within the districts which are drained on the combined system, undrained areas, principally undivided estates, which would be naturally drained on that system.

Commissioner DANA. I supposed that was what you meant. Have you or not established any plan to change the combined system into the separate system?

Mr. FRENCH. There is none, excepting that for fifteen years past it has been the uniform rule to build all the new sewers on the separate system wherever it was possible to discharge the surface water into brook channels at reasonable expense.

Commissioner DANA. Now, I did not quite understand one part of the letter. There was one phrase there, whether

you thought — whether there was any part which would have to be permanently on the combined system, from the nature of the ground, or what was it?

Mr. FRENCH. I do not recall the part you refer to.

Commissioner DANA. That phrase is "largely of the combined system." That does not mean that it is necessarily combined, but only that it exists at the present time, and that it would be expensive to change it; is that it?

Mr. FRENCH. That is all I meant; yes, sir.

Judge DUNBAR. Have you made any estimate, or is there any basis for making an estimate, of the expense to the town of changing the level of the water?

The CHAIRMAN. Say the 8 foot level.

Mr. FRENCH. No, I have made no estimate.

The CHAIRMAN. That would be perfectly feasible, — to compute the cost which would ensue, wouldn't it?

Mr. FRENCH. Yes, although involving a good deal of detail; some of the elements of cost being extra pumpage, the filling of certain low lands, the separation of the storm water from the sewer system, and some other matters of less importance.

Mr. DUNBAR. Have you any idea, Mr. French, how much it would cost to change your whole system of sewerage in Brookline from the combined to the separate system?

Mr. FRENCH. No, sir.

Mr. MATTHEWS. May I venture to ask you to bring a diagram of St. Mary's Street sewer, or that sewer you were talking of?

Mr. FRENCH. Yes, if the data already furnished is insufficient.

Mr. MATTHEWS. I would like vertical sections and levels.

Commissioner DANA. Does this map give the levels at all?

Mr. FRENCH. It is a general map, on which the sewers are shown, and some figures indicating elevations but giving no vertical sections.

Commissioner DANA. Merely whether the areas are sufficiently given on the map to show the grade of that sewer, and the height.

Mr. FRENCH. The map gives that information. For instance, the elevation of the invert of the trunk sewer at the junction of Carlton Street and Beacon Street is 3.06 feet, and the crown of the sewer at the same point is 10.48 feet.

Mr. MATTHEWS. Did you state the tide water?

Mr. FRENCH. Yes, sir. The figures are referred to Boston city base, as it is called, which is low spring tide.

Mr. MATTHEWS. That would be shown on the profile?

Mr. FRENCH. Yes; I think it could be better shown in the form of a profile than in any other way.

Mr. GOODENOUGH (engineer of the State Board of Health). The State Board of Health has your letter, and has been collecting information for you. The only public work at the present time is the work in connection with prevention of pollution of streams and sewer outlets, which was commenced last year. That work was only commenced last year, and has not advanced very far. The Board hopes to give you an answer to your letter by the 22d instant. I have the map of the original commission which investigated this matter of the Charles River dam, which we will be happy to give you, if you desire it.

The CHAIRMAN. Mr. Hollyday, of the United States Navy, civil engineer at the Charlestown Navy Yard, is present, I understand; and, as the Navy Yard is interested in this matter, we would be very glad to have any information which he may care to give us.

Mr. R. C. HOLLYDAY. I appear here to give any information which any gentlemen may desire; I have no report to make.

The CHAIRMAN. There was no information specially which you could give us, no data concerning the Navy Yard, which the authorities there desire to put on file in connection with the consideration of such a plan as is proposed?

Mr. HOLLYDAY. No; I simply appear to give any information which the commission might desire.

The CHAIRMAN. Thank you very much. There was no information concerning the present depth of water in front of the Navy Yard?

Mr. HOLLYDAY. Yes; I have a map here, showing surveys from 1835 to 1899, for their information, if they desire it.

The CHAIRMAN. Thank you very much. That information and those surveys are of course accessible to all the members of this commission, as well as any one else, as far as that is concerned.

Mr. T. T. Hunter Harwood, engineer in the United States engineers' office, presented the following letter from W. S. Stanton, Lieutenant-Colonel, Corps of Engineers, United States engineers' office, Boston, Mass.: —

JAN. 13, 1902.

Mr. HENRY S. PRITCHETT, *Chairman, Committee on Charles River Dam, Boston, Mass.*

DEAR SIR: — In response to your request of Dec. 16, 1901, I have the honor to transmit herewith the following reports: —

Appendix C of the annual report of the chief of engineers, U. S. Army, for 1901, stating, on pages 151–154 and 1077–1083, the scope and the present condition of the improvement of the entrance channels to Boston harbor and of the tidal streams tributary to its upper part.

The report now before Congress of the survey and estimates for further improvement of entrance channels will be found in House Document, No. 119, Fifty-sixth Congress, second session.

I also transmit herewith the following reports, and drawings illustrating them: —

Reports.

Appendix B, annual report of the chief of engineers for 1899, containing original report of the survey of Mystic River below the mouth of Island End River, with a view to its improvement.

Appendix A, annual report of the chief of engineers for 1881, containing original report of the survey of Malden River; and Appendix B, annual report of the chief of engineers for 1891, containing original report of the survey of Mystic River and additional report upon Malden River, with a view to their improvement.

Appendix B, annual report of the chief of engineers for 1895, containing original report of the survey of Chelsea Creek, with a view to its improvement.

Appendix A, annual report of the chief of engineers for 1879, containing original report of the survey of Charles River, with a view to its improvement.

Pamphlet report (House Document, No. 113, Fifty-fifth Congress, second session), survey of Boston harbor, Mass., embracing the Broad Sound channel project of 1897, with lithographed plan, with a view to its improvement.

Maps.

Fort Point channel; Mystic River, below the mouth of Island End River; Mystic and Malden rivers; Chelsea Creek; Charles River; tracing of Boston upper harbor, showing location of the main ship channel, 1,000 feet wide and 27 feet deep at mean low water, project of 1892 (no report on this project has been printed, for which reason none is furnished); coast survey chart, intended as key map to above plans, having indicated upon it the location of the several improvements.

Mr. T. T. Hunter Harwood, the assistant engineer in this office, by whom the surveys were in great part made upon which the reports and maps are based, will, upon your request, supplement, so far as he may be able, by oral statement before the committee, the information which they give.

I beg to say that Mr. Harwood, in representing this office, is not authorized to make any statements before the committee other than statements in explanation of the information given by surveys and reports which he himself made.

Very respectfully, W. S. STANTON,
Lieutenant-Colonel, Corps of Engineers.

Adjourned until 10 A.M., Wednesday, Jan. 15, 1902.

THIRD HEARING.

ROOM 240, STATE HOUSE EXTENSION, BOSTON, Jan. 15, 1902.

The hearing was begun at 10 A.M., Chairman Pritchett presiding.

Mr. JOHN E. ABBOTT. Mr. Chairman, if I may be pardoned to make this suggestion, I represent the town of Watertown. I am counsel for the town of Watertown. The overwhelming sentiment of the town of Watertown, based upon the conditions which have so long existed, is in favor of a dam across the Charles River, either in the vicinity of Craigie bridge or of West Boston bridge. I desire to present herewith a letter from the town, which the Board may desire to place on file: —

WATERTOWN, MASS., Jan. 15, 1902.

JOHN E. ABBOTT, Esq., *Town Counsel of the Town of Watertown.*

DEAR SIR: — You are hereby notified that at a meeting of the board of selectmen, held Dec. 27, 1901, it was voted to request you to be present and to represent the town of Watertown at the hearings to be held on the question of building a dam across Charles River.

Yours very respectfully, FRED E. CRITCHETT,
Town Clerk.

Chairman Wm. B. de las Casas of the Metropolitan Park Commission submitted the following report: —

Extract from the records of the four hundred and eighty-third meeting of the Metropolitan Park Commission, Dec. 11, 1901: —

Voted, That the Metropolitan Park Commission requests and authorizes its chairman to appear, or designate some other member or the secretary of the Board to appear, before the special committee appointed under chapter 105 of the Resolves of 1901, and to express the opinions and views of this commission in regard to the matter of the feasibility and desirability of a dam across Charles River.

Voted, That as a basis of such expression of opinions and views, this commission records its belief that the health and welfare of the community will be benefited by maintaining a water level as nearly as possible permanent in the Charles River between Craigie bridge and the dam at Watertown, and its further belief that it is possible at this time to provide economically for such permanent level by structures and regulations which will secure for that river healthful conditions, improved commercial opportunities and greatly increased usefulness as a water park.

A true copy. Attest: JOHN WOODBURY,
Secretary.

BOSTON, Jan. 11, 1902.

Committee on Charles River Dam, 14 Beacon Street, Boston.

GENTLEMEN: — The Metropolitan Park Commission presents, in response to the request in your letter of Dec. 16, 1901, certain data in regard to Charles River, under the following heads: —

I. Summary of important plans, reports and legislation.

II. Summary of holdings for park and other public uses along the river.

III. Relation of Charles River as a park to the metropolitan district and parks.

IV. Present and future development and use of the river.

V. Illustrative maps and plans.

I.

Boston has grown from a population of 24,937 in 1800 to one of 564,892 in 1900; Cambridge in the same time has grown from 2,453 to 91,886; and the cities and towns comprising the metropolitan parks district now have a population of 1,164,957, as against less than 60,000 in 1800. The original topography of Boston and its neighborhood was ill suited for so large a city. The growth of population has brought changes in its topography such as few cities of the world have known, and the solution of many incidental problems. These changes and problems have been especially marked in and about Charles River. It is the longest river in the district, and its earliest use was as a water way. Beautiful houses were placed upon the overlooking hills for the sake of the views across the intervening meadows and marshes, while little wharves and mills upon its banks met the business requirements of the villages along its course. The upper or fresh water portion was a series of shallows and falls which soon attracted factories and mills, and five dams were built across it to utilize its water power. These dams and some of the factories still remain.

The lower or tidal portion of the river was an estuary or inlet of the harbor of considerable area, but of little depth of channel. With the growth of population efforts were made to utilize this area by building dams and restricting the water channel, and by extensive filling for the necessary growth of business buildings and of dwellings, until the tide was excluded from fully 60 per cent. of the area over which it once flowed.

With the building of many bridges and changes in methods of transportation, the river began to lose importance for commerce and other business. Wharves diminished in number and importance, and its low banks were occupied by cheap buildings with dirty surroundings. Its waters became foul with the sewage of the adjoining cities and towns, until problems of health and sanitation required the exclusion of sewage by the costly Boston and metropolitan sewerage systems, and the cleaning off and filling of its banks. Charles River, like many rivers in the midst of great cities in the old world, has now come to be of more importance as a water park in the midst of a great population than as a place of business or commerce.

The principal events marking the change of Charles River to its present condition may be summarized as follows: —

Mill pond between Beacon Hill and Copps Hill dammed off at a very early date, then filled from 1804 to 1830.

1814. Mill dam authorized from Boston to Brookline, now Beacon Street, cutting off, as estimated on map of the time, 660 acres (the present tidal area of Charles River is about 894 acres).

The map of this project included also a project for a dam across Charles River, at about the site of the present Harvard bridge.

1870–93. Boston and metropolitan sewerage systems, excluding sewerage from Charles River.

1876. Boston Park Commission, second report, suggested embankments along the river.

1881. Boston Park Commission authorized to build Charlesbank.

1891. Charles River Improvement Commission appointed (chapter 390 of Acts of 1891); two reports, 1892 and 1893.

Boston Park Commission authorized to extend embankment along Charles River to rear of Beacon Street.

Cambridge authorized to acquire shores of the river and construct parkway.

1893. Boston Park Commission authorized to extend embankment to Fens (chapter 435 of Acts of 1893).

Preliminary Metropolitan Park Commission report, under chapter 342 of Acts of 1892.

Metropolitan Park Commission established (chapter 407 of Acts of 1893).

Metropolitan Park Commission and State Board of Health as a joint Board, required to investigate the sanitary condition and report plans for the improvement of Charles River to Waltham line (chapter 475 of Acts of 1893).

1894. Metropolitan Park Commission authorized to build parkways and boulevards.

Report of joint Board on improvement of Charles River, recommending: (1) acquirements of the shores of the river; (2) a dam between Craigie and West Boston bridges; (3) filling along right bank, etc.

Metropolitan Park Commission authorized to acquire the shores of Charles River (chapter 509 of Acts of 1892).

Board of Harbor and Land Commissioners directed to inquire into the construction of dam and lock in Charles River, as proposed in report of joint Board, with special reference to interference of tide water and its effect on Boston harbor (chapter 85 of Resolves of 1894).

Joint Board directed to investigate and report on the improvement of Charles River above Watertown (chapter 529 of Acts of 1894).

1895. Harbor and Land Commission reported as to effect of proposed dam on Boston harbor with the following statements (page ix): "It is unable to say, in view of the irreconcilable testimony of experts given at the hearings, that the conclusion of the joint Board may not justify the experiment, so far as sanitary objections are concerned." And on pages xix and xx: "Moreover this Board is powerless to say, on the imperfect information it has, what effect a dam as proposed would have on shoaling in the upper harbor. We must, however, record the opinion that nobody knows what the effect would be. Upon a careful consideration of the testimony presented, and of all the evidence within the knowledge of the Board, we are unable to find the consequences of building the proposed dam as at all certain of being foreseen; and, in view of the incalculable injury which might ensue from impairing the usefulness of the harbor, we are unable to report in favor of the recommendations contained in the report of the joint Board."

1896. Joint Board reported on upper Charles River, recommending: (1) high-water surface be made a portion of the metropolitan park system; (2) a water-level as nearly permanent as possible; (3) arrangements for transfer of boats over the dams; (4) that lands and rights be taken along the banks; (5) public control of banks and waters.

1898. Metropolitan Park Commission directed to construct a dam with suitable lock or locks across the Charles River, from a point at or about the intersection of St. Mary's Street extended in the city of Boston.

Appropriations for the purpose of acquiring banks of the upper river.

1900. Metropolitan Park Commission authorized to make rules and regulations for public use of Charles, Neponset and Mystic rivers, and directed to report on the matter of securing a permanent water level.

The maps A, B and C, accompanying this letter, are illustrative of the former area and topography of Boston and its neighborhood. Upon these maps lines have been marked showing the changes to the present area, especially in the neighborhood of Charles River, and marking the position of the mill dam, now Beacon Street, which was built 1814–18; and of the other dam across Charles River, proposed as part of the same plan, but never built.

II.

The banks of Charles River are now largely owned or controlled by public bodies.

Above the first dam at Watertown, for a distance of about 18 miles, this control is in the Metropolitan Park Commission, and in the cities and towns bordering on the river or having the right to take water from the river and lands nearby. Below this dam, that is, on the lower river, the ownership of the banks for almost the entire length on both sides as far as Craigie bridge is in the United States government at the arsenal grounds, in the Commonwealth between Essex Street bridge and the new Cambridge bridge, and in its Metropolitan Park Commission and in the cities of Boston and Cambridge through their park commissioners as to most of the remaining river banks.

The following tables give the principal facts as to the former and present tidal areas of Charles River, and as to present bridges, distances, areas and ownership: —

Tidal Areas, Charles River Bridge to Watertown Dam.

	Acres.
Original area, ...	2,250
Present area, ...	894
Decrease, 60 per cent., or	1,356

Distances, Craigie Bridge to Watertown Dam.

	Thread of Stream.	Right Bank.	Left Bank.	Both Banks.
Distances in feet, . .	46,025	47,030	44,870	91,900
Distances in miles, . .	8.71	8.90	8.50	17.40

Bridges and Distances along Thread of Stream.

From Charles River bridge to: —	Feet.	Miles.
1. Warren bridge,	620	.12
2. Fitchburg Railroad (two draws),	1,000	.19
3. Boston & Maine Railroad to car yard,	1,300	.25
4. Boston & Maine Railroad, Union Station tracks (two draws),	1,640	.31
5. Southern division, freight tracks,	2,510	.47
6. Craigie bridge,	2,890	.55
7. West Boston (no draw),	5,410	1.02
8. Harvard,	11,580	2.19
9. Grand Junction Railroad,	16,790	3.18
10. Essex Street (or Brookline Street, Cambridge),	17,030	3.22
11. Cambridge Street (or River Street),	21,150	4.00
12. Western Avenue,	22,260	4.22
13. North Harvard Street (or Boylston Street),	25,340	4.80
14. Western Avenue (or Arsenal Street, Watertown),	36,005	6.82
15. North Beacon Street,	39,955	7.57
16. Galen Street (no draw),	47,925	9.08
17. Watertown dam, at head of tide water,	48,915	9.26

Distances scaled from copy of plan prepared for joint Board, October, 1893.

Ownership of Banks.

	Distances (Feet).		
	Public.	Private.	Totals.
Craigie Bridge to Essex Street Bridge.			
Right bank: —			
Bay State road and Charles River embankment (includes proposed embankment),	14,280	-	-
Cousens wharf,	-	320	-
Total right bank,	-	-	14,600
Left bank: —			
City of Cambridge,	10,800	-	-
Damon, Coleman Brothers and Smith properties,	-	1,500	-
Total left bank,	-	-	12,300
Essex Street Bridge to Watertown Dam, at Head of Tide Water.			
Right bank: —			
Brookline Gas Company wharf,	-	500	-
Abattoir, of which 400 feet is leased wharf,	-	3,400	-
Newton and Watertown Gas Company and others,	-	1,900	-
State of Massachusetts, metropolitan parks,	26,630	-	-
Total right bank,	-	-	32,430

Ownership of Banks — Concluded.

	Distances (Feet).		
	Public.	Private.	Totals.
Left bank: —			
City of Cambridge, ...	12,000	-	-
United States arsenal, ...	5,150	-	-
State of Massachusetts, metropolitan parks, ...	14,680	-	-
H. & W. Paper Company, Lewando's and others, ...	-	740	-
Total left bank, ...	-	-	32,570
Totals (feet), ...	83,540	8,360	91,900
Totals (miles), ...	15.82	1.58	17.40

From these tables it appears that, of the 91,900 feet measured by both banks of the river between Craigie bridge and the head of tide water, there is in private ownership 8,360 feet, of which 2,880 feet only is occupied by wharves belonging to private owners.

Craigie bridge is the seventh bridge and its draw the ninth draw. The first wharves are between that and Cambridge, and the next wharf is above the ninth bridge, the next above the eleventh bridge, and the remaining wharves are above the fifteenth bridge.

The total ownership of the banks is divided as follows: metropolitan parks, 41,310 feet; Cambridge parks, 22,800 feet; Boston parks, 2,200 feet; Commonwealth between Cambridge bridge and Willard and Abbott wharf, 12,080 feet; and the United States arsenal, 51,150 feet; making a total of 83,540 feet in public ownership and 8,360 feet in private ownership.

III.

The policy pursued by the Metropolitan Park Commission in its acquirements and work along Charles River bears a definite relation to that pursued by the other public bodies along the same river. The same policy has been pursued in its acquirements throughout the metropolitan district. No acquirements have been made in a haphazard manner for the mere purpose of providing parks, but all have been made with reference to and as parts of a well-devised and logical plan to make these acquirements and the larger local parks form a single great metropolitan system, in which each park should supplement the others. This will be understood from the comparison of Map D, which was the map submitted by the preliminary Park Commission of 1893, with Map E, which presented a later and more detailed working out of the plan in 1898, and Map F representing the actual park areas of the district at the close of the year 1901. A thorough knowledge of the district and each of the reservations and parkways inevitably leads to the conclusion that no portion of what has already been acquired could be given up without marring not only the æsthetic completeness, but even more the practical usefulness of the whole proposed system; and it is but a trite observation to say that the full value of what has been acquired with such care can be reached only by equal care and deter-

mination in gradually developing and improving the acquirements to their complete beauty and use.

Charles River is the central feature of the metropolitan park system, both as a water way and as a parkway. It runs west through the entire district and then south along its south-western boundary. The Fens and the parks and the parkways of the southern half of the district trend towards this river; and Fresh Pond, Revere beach and the Middlesex Fells parkways trend towards from the north. It will inevitably form a line of approach from all parts of the district to Boston and from Boston towards all parts of the district. It is the only river within the district of a size and length which suggests and already has been used as a water way and water park, affording opportunities for use of its water by river craft and for all the various sorts of river sports, and for the use of its shores for drives and walks from which the river and its sports may be reached and its beauty and varied life enjoyed. Charles River is, therefore, in a merely practical business sense, essential to the attractiveness of Boston and of the entire park system, while as a recreation ground its place cannot be supplied even now by any other portion of the parks or by any other tract of land or body of water near Boston.

IV.

So long as private ownership and use controlled the development of Charles River, its future was uncertain. Unforeseen conditions have changed its relation to the life of the community, and made it one of the most interesting water parks of the world. For years before any acquirements were made by the Metropolitan Park Commission, the upper or fresh water portion of the river was a favorite resort of canoeists, and the open stretch between Moody Street bridge, Waltham, and Newton Lower Falls, was more largely used for pleasure boating than probably any other equal portion of any river in this country. So popular had it become that rowdyism and private greed began to show themselves unpleasantly. The acquirement of its shores and control of its waters was urged, as the only means of preserving its beauty and usefulness, and the Legislature made large appropriations to that end. Map G of the public holdings on this portion of the river shows that nearly all the shores as far as Newton Upper Falls have now been placed under the control of the Metropolitan Park Commission, through takings of the fee or of restrictions, except where large business enterprises have prevented, or well-cared-for private estates have made such control unnecessary. Very simple development has followed. Unsightly buildings have been removed, unattractive lands are being graded or cleared of rubbish, and some care is being given to the trees and shrubbery. A river police has been established, and in two years has checked the tendency to disorder and has rescued 61 persons from drowning. Recreation grounds and boat houses have increased in size, and there are now 2,471 boats and canoes owned upon this stretch of the river. It is not easy to describe the exquisite charm of the upper river, or the extent and variety of ways in which it is enjoyed by the public; but no one who has seen its use on a spring or summer afternoon or on the evenings when illuminations and music are provided by the boat clubs, and has watched the throng of canoes and boats covering the entire surface of the water from shore to shore, can doubt that this portion of the river will always be a water park, or that in the future the recommendation of the joint Board for a permanent water level and for locks and carries around the dams will be realized. It is equally certain that one of the strongest demands for such improvements

will come from the increasing number of those who live about the lower river, and who feel that it is reasonable that they should enjoy both parts of the river, and be able to pass freely from one to the other.

The tidal character and unattractiveness of the shores of the lower river and the constant change in its business uses have until quite recently discouraged its general use as a place of recreation; but the time has now come when its use as a water park is so well determined that all plans for its development and care must give large consideration to such use. A comparison of the early maps of Boston with those of to-day shows plainly how the present condition of the river has been the logical result of the necessities of a rapidly growing population and the change in business. The mill dam, now Beacon Street, cut off a tidal area of about three-fourths of the size of the present tidal portion of the river, in order to provide a storage basin for the operation of tide mills; but the growing population forced these mills aside, and required the area for residence in the Back Bay, and the park improvements about the Fens is the result. One can easily agree with the statement in the "Memorial History of Boston" (Vol. 4, page 32), that this is "the event which more than any other determined the future of Boston, and which ultimately led to a complete change in its physical conformation." The building of many bridges and the increasing size of vessels drove business from the river, and left its shores in neglect until finally public interest forced the cleaning of the river and improvement of its banks. In 1881 the Boston park commission acquired and began to develop Charlesbank as an embankment, 2,200 feet long and 200 feet wide, between Craigie and West Boston bridges. The beauty and usefulness of this work has been a most valuable object lesson. The same board has secured legislative authority to extend this embankment as far as the Fens, but has never been provided with the means to carry out the improvement. As the harbor line is at the present wall, this improvement may be considered as reasonably certain to be carried out and even extended to Essex Street bridge, as other improvements along the river are advanced. Boston is understood to have already expended in this improvement $685,000. On the opposite bank, the city of Cambridge entered upon the work of reclaiming its shore by concessions to an embankment company in return for filling the marshes and building a public esplanade, and has ever since steadily carried forward a plan of park development supplementing this embankment, which is perhaps as far-sighted and attractive as any city of its size has ever entered upon. When completed this work will make an esplanade 22,800 feet long, leaving only 1,500 feet of its entire river frontage in private ownership, exclusive of the wharves on Broad Canal. It is understood that Cambridge has already expended, in addition to the cost of the work of the embankment company, about $1,000,000. The remaining shore front of the tide part of the river is almost entirely controlled by the United States government at the arsenal grounds and by the Metropolitan Park Commission. The commanding officer at the arsenal has signified his approval of the idea of continuing park development along the front of the arsenal grounds, and the Park Commission has already made good progress in the development of the shore under its control. Between North Harvard and Western Avenue bridges a dike 2 miles in length encloses a meadow park, driveway and mile speedway, on the right bank; while on the left bank, between the arsenal and Watertown landing, a road is now being built which passes along the edge of old estates with fine trees, which will in the coming year provide a mile of beautiful parkway. This commission will then have expended nearly $2,000,000 in lands and construction along the upper and lower Charles River.

The large expenditure and work by State and municipality will gradually make a continuous park on both sides of the river, with walks and drives, from the heart of Boston, as far at least as Watertown, and connecting with the parks in all parts of the district. At the same time other necessities will cause the renewal of the present ugly and inadequate bridges in more ample and attractive form, of which the new Cambridge bridge is to be the first example; but when all is done there will still be, if other present conditions continue, a serious blemish on the full beauty and usefulness of the river and park in the rise and fall of the tide, which will continue to bring filth from the harbor and deposit it on the long slopes of the river banks, and in the narrow channel, which will be left at low tide on the 6 miles of river above Essex Street bridge. Then public necessity will require that any shortsightedness of to-day be remedied at increased expenditure, and a permanent water level be maintained in the otherwise superb Charles River park, — the court of honor and of recreation of metropolitan Boston.

Is this a dream? Then it was a dream when men laid out the Common, Commonwealth Avenue, the Fens, or, to look at the example of other cities and countries, when L'Enfant planned Washington, when the Thames embankment was laid out, the Richmond tidal bridge and lock built, the Alster basin in Hamburg created by a dam, or the Champs-Élysées laid out in Paris. The opponents of present improvements say you would cut off our view of the river; you would make a sewage pond of Charles River; you would drive us out of business; and, finally, you would destroy Boston harbor. No, we want no such results; we simply say there is a march of events which is surely making Charles River a decent, useful and even beautiful water park, and this march of improvement is reasonable and necessary, and cannot be averted. It does not rest in the plans and wishes of the Park Commissioners or of artists or of æsthetical improvement associations, but upon the necessities of the enormous and growing population. The suggested permanent water level will each year become more and more a public necessity, and will finally be provided by some artificial structure, either as a part of the bridges which must be rebuilt or an independent structure. At Craigie bridge or Cambridge is the logical position for such a structure; and Craigie bridge is now inadequate, and so old as to be almost unsafe; and Cambridge bridge is being built, and not so far advanced but that its plans may be amended. It is, therefore, to-day a matter of financial prudence to consider the problem, and decide whether a dam cannot be built most economically as part of rebuilding Craigie bridge, or at least whether Craigie bridge ought not to be rebuilt on lines which will permit the building of a dam at some time in the near future. In the consideration of this question the Metropolitan Park Commission joins the other proponents, suggesting that you consider: (1) that the time and method of building an embankment from Cambridge bridge to the Fens may be safely left as it is now by legislative authority to the city of Boston itself; (2) that the sanitary requirements for the sewering of Boston, Cambridge and Brookline may be provided for by such extension or partial reconstruction of its present system as may be found necessary, just as such problems were provided for in connection with the damming off, filling up and sewering of the Back Bay, when the mill dam was built, and Cambridge marshes when the Cambridge embankment was built; (3) that the exact number and magnitude of the private business interests to be affected and their relation to the necessities of the community as a whole be accurately estimated and provided for in any plans which may be

decided upon, and that, so far as this cannot be done, provision be made for their compensation; (4) that whatever plan be recommended shall not impair the general business interests and necessities of the entire community in preserving and improving Boston harbor, without providing for such compensation to prevent any possible shoaling of the harbor channels as may be required by our own Board of Harbor and Land Commissioners, or as the Secretary of War may require under the act of Congress which places that power in his hands to use as he may deem necessary.

In brief, the Metropolitan Park Commission believes in securing as nearly as possible a permanent water level on the lower Charles River by a dam at or near Craigie bridge or Cambridge bridge, provided the result can be secured in a way which shall protect every other public interest by compensation or substitution of an equivalent for anything taken away, and by compensating every private interest which may be injured, as in any other case of public improvement at the expense of private interests. It asks your committee to do what it has every confidence you will do, — ascertain the method and amount of such compensation and substitution as will be necessary to protect every other interest, and then to state plainly to the public the terms and conditions upon which this desired public improvement can be equitably carried out. We have no plan to propose, and we do not ask you to be bound by the details of any plan heretofore proposed for accomplishing this result.

V.

We submit certain illustrative maps and plans, as follows: —

A. Copy, plan of Boston, 1729.

B. Copy, topography of Boston and vicinity, 1775, with location of dams proposed in 1814 and present lines of Charles River added.

C. Boston Board of Survey, map, 1896, with original areas traced upon it.

D. Map of metropolitan park proposed by Charles Eliot to preliminary Metropolitan Park Commission, 1892.

E. Map of metropolitan and local parks and additions proposed, 1898.

F. Map of metropolitan and local parks acquired to 1902.

G. Map of metropolitan and local holdings, upper Charles River, to 1902.

H. Map of metropolitan and other park land, quasi-public holdings, lower Charles River, to 1902.

All of which is respectfully submitted,

WM. B. DE LAS CASAS,
Chairman.

Q. (by Commissioner DANA). What is the area of the present tidal water that would be cut off by the dam at St. Mary's Street? Have you calculated that? A. I have not calculated that.

Mr. Casas sent the committee the following statement: —

The present area of water surface at mean high tide above a line drawn across the river at St. Mary's Street normal to the thread of the stream is 293 acres; at mean low tide, 171 acres; leaving flats and sloping banks exposed at mean low tide, 122 acres.

Q. (by Mr. MATTHEWS). Mr. Casas, can you tell the committee how much of those areas shaded green in map have been acquired since 1894? A. All of them, that is, as far as the Metropolitan Park Commission is concerned.

Q. And that is true also, is it not, as far as the city of Cambridge is concerned? A. Substantially all. I think the act authorized them. I think they were authorized in the act prior to the report of the joint Board.

Q. With the exception of the Charlesbank, is there any of that land colored green below the Charlesbank that was public property at the time this question was considered by the joint commission in 1894? A. Not that I know of, unless you consider the Watertown arsenal public property.

Q. With the exception of that, then, all changes have taken place since 1894? A. The first appropriations for acquirement by the Commonwealth were made immediately following the consideration of the question by the joint Board in 1894, by the committee and Legislature.

Q. (by Mr. DUNBAR). What is this you say the Commonwealth owns there in connection with Beacon Street? A. The harbor line, I understand, along the line of the wall on Beacon Street, Back Street.

Mr. DABNEY. The flats are there, but they do not belong to the Commonwealth; I think they belong to the abutters.

Mr. MATTHEWS. If there is any doubt, I shall be very glad to learn that they belong to us. I do not think they belong to us; I think they belong to the Commonwealth. I have had occasion to look into the matter, and I think they belong to the Commonwealth.

Mr. DABNEY. And I have also had occasion to look into the matter, and I think they belong to us.

Q. (by Mr. DUNBAR). The act of 1898 authorizing the construction of the dam at St. Mary's Street, or Cottage Farm, — you have considered this to some extent. Does the commission now abandon the position which it held before with reference to that dam, — in securing the passage of the act? A. We did not secure the passage of that act; we assented to it. If you will look at the petition, I think you will find Cambridge and Watertown had it passed.

Q. Well, there may be some misunderstanding about that. I understood that the Park Commission petitioned for the passage of that act. A. We approved it at that time; yes, sir.

Q. So that the position of the Park Commission has been changed since then, has it? A. No. We suspended action

on it for several reasons; one reason was, that after the passage of that act there was not a dollar to be expended under it. Moreover, we were met by remonstrance from all the boating men on the river that their opportunity to use the river would be interfered with, and as a result of such dam that it would be impaired; and we felt that under those circumstances it was not necessary to hurry the matter; and we found also that the city of Boston was not prepared at that time, and had no authority, to make any changes in the stream which would bring any approach whatever to it, and the sums we had were entirely insufficient to make the necessary changes. A number of defects would have to be remedied, but the real and fundamental reason in regard to it has been that there was such a decided feeling of unrest in the community, that until it could be determined that there could not be a dam placed at a lower point on the river, it would be better not to attempt the work at all.

Q. You spoke about the work of Cambridge upon the left side of the bank, — that's what you call the parkway, is it? A. The embankment; the general term parkway, yes, or river front, apply.

Q. Has that work below St. Mary's Street been done with reference to the erection of a dam at St. Mary's bridge? A. The original plans all carried the idea of a road which should rise over the Grand Junction Railroad track.

Q. The dam at St. Mary's Street, I mean. A. Yes. You asked me whether the Cambridge work had been done with reference to a dam at St. Mary's Street, and I said it carried the idea of a road running over the Grand Junction Railroad, and the site of the dam was suggested by Mr. Charles Eliot, making a basin, as he called it, to be formed by this dam, — a tidal basin between the harbor and that point.

Q. Which point? A. The suggested dam at St. Mary's Street; a formal treatment of walled tidal basin that would connect with the plan that was adopted at least in part for carrying the road over the Grand Junction Railroad. It has not been determined yet in what way the Grand Junction Railroad will continue its track across there, whether the tracks will be depressed or elevated; but it was assumed that the tidal basin might be adopted in either case; that is, if the tracks were depressed, this would be convenient; if the tracks were raised, it would allow of convenient passing under the tracks, — so that to that extent it was planned with reference to the plans of the Cambridge park commis-

sion. It so happened that at that time the same architect was engaged by our commission and the Cambridge park commission, and so the plans may have perhaps had some uniformity.

Q. Then, in short, this work was adopted or this plan was adopted with a view to harmony with the St. Mary's Street dam? A. I could not say. I say that when the matter was adopted, it was proposed on the lines which would harmonize the two plans. I do not know what Cambridge had in mind.

Q. Well, the work is adapted to a tidal basin, isn't it, along the river bank? A. I should leave the Cambridge commission to speak for that, but I should think it was.

Q. I did not observe that you put anything in your report about an esplanade along the river; did you put anything in your report in regard to that? A. We have not.

Q. Do you favor that? A. As a general proposition, I should think everybody should do so.

Q. Have you had any occasion to consider it for some time? A. We have never considered it except at the time and in the way we did when we were part of the joint Board.

Q. Were there plans in possession of your commission that you examined for the esplanade along Beacon Street from the Beacon Street residents? A. Oh, yes; there was a plan suggested to us, which we did not consider attractive. That plan provided for a paved way about 40 feet wide.

Q. (by Mr. Dabney). A paved way? A. Yes. One of the plans at least which was suggested. Another plan, I think, was for an elevated wall. One of the plans at least involved a paved way; I do not know whether it was the plan suggested by Mr. Dabney, or not.

Mr. Dabney. I never suggested a paved way.

Q. (by Mr. Dunbar). As I understand your suggestion, it contemplates the retention of all the water area of the present basin. A. I have no plan. I do not know anything about any plan that has been suggested. I should suppose that that might be left to the local authorities. Authority has already been granted to the city of Boston by the Legislature to look after the embankment there; and I should suppose that it might be left there with them, and they might be allowed to decide what they want to do in the treatment of their own shore. I do not know of any prospect or any desire on the part of our commission to have anything to do in the treatment of what may be considered a local question.

The Chairman. I understand that your report simply

shows what relation such improvements might have to the metropolitan park system. That is what we desire.

Q. (by Mr. HAMLIN). Will you state, Mr. Casas, what is the area of the flow? A. That I do not know. I think you will find that very carefully stated in the report of the joint Board by Mr. Stearns, who was the engineer and who is now the engineer of the Water Board.

Q. (by Mr. MATTHEWS). You stated that work practically on the Cambridge side of the river was a walled basin. A. It is simply a walled basin; if the water were established at grade 8, it is higher than would be required otherwise; if it is a walled basin, it is adapted. It was built by the Cambridge Improvement Company, I understood.

Q. (by Commissioner DANA). That wall is not yet completed? A. The Cambridge wall —

Q. I mean all the way up to the Essex Street bridge. A. Oh, no; it is not entirely completed, but I understand they drove their sheet piling and bulkhead this last summer, and then began filling the marshes, and behind that expect to adopt other treatment subsequently.

Q. (by Mr. DUNBAR). Will you tell me where Essex Street is? Do you mean Cottage Farm bridge? A. Yes; that is called by a good many different names, — Essex Street, Brookline Street and Cottage Farm.

Mr. ABBOTT. Col. J. G. Butler, the commandant of the Watertown arsenal, is present, and, if it is agreeable to the commission to receive a statement from him in regard to this matter at the present time, he will make it.

Col. J. G. BUTLER. Mr. Chairman and gentlemen, I am very glad of the opportunity to be present, but it would hardly seem worth while for you to expect that I might have anything special to say upon this subject. My friend Mr. Abbott has suggested that I express to the Board at this time my hearty appreciation of the object and the purposes of this commission. To a limited extent, perhaps, I represent the United States government, that is, so far as my recommendation may have any weight in the matter concerned; and I would say that so far as that recommendation would go, it would be of the heartiest kind. Anything that would improve Charles River valley must redound to the benefit of the government and of the arsenal and of the community in general; and my recommendation would certainly go to the extent of the cession of any reasonable amount of territory to assist in the carrying out of this enterprise; for instance, to the extent of ceding territory for the running through of a boulevard along the river

front, which I understand to be one of the projects contemplated.

Q. (by Colonel MANSFIELD). Colonel Butler, is this your personal statement, or are you authorized to make this statement as a representative of the ordnance department? A. No, it is my own personal opinion and recommendation.

Q. You have not referred the matter to the head of your department? A. The matter has been referred to the head of the department, and in my annual report I referred to the commission and to the fact that I was in communication with your commission, and had given you certain facilities and services in this connection, and also to the fact that my recommendation would be in the direction of favoring the project; and I know that now my department is favorable to the operations of the commission. I could not say as to the Secretary of War; of course, the matter goes beyond the ordnance department, — it goes to the Secretary of War.

Q. Yes. I was simply desirous of knowing whether this was an expression on your part in behalf of the ordnance department, or simply an expression of your personal views. A. My own personal views. Beyond the ordnance department is the Secretary of War. I cannot speak with quite the authority that Colonel Mansfield of the engineers can; but so far as my department is concerned, my opinion is it would be entirely favorable, — that is, favorable to the building of a dam and the maintaining of a constant level of water, as I understand it, subject, however, to the outflow and refilling. I presume the dam would contemplate some such plan as that. If any dredging was at any time desirable, it would be perhaps easier to dredge in shallow water than in deep water; and, so far as maintaining the level of the water, I do not see how that is going to interfere in the slightest degree with the wharf privileges at the arsenal. I have no knowledge of any freight of any kind having been received at that dock for years. The railroad facilities at that point are so good, — the Fitchburg road and the Maine road have switches there, and the railroad facilities are so good that all my goods are delivered by rail or by wagon; and not with my recollection has there been anything in the way of freight delivered at that dock; so that I do not think the interest of the arsenal would be impaired in the slightest degree, while it would share in the general improvement in that section.

Q. (by Commissioner DANA). You said nothing had been received at that wharf. Were any things sent from

the arsenal wharf, in your recollection? A. No, sir, not that I know of; at this moment I do not recall anything.

Q. When you sent the ordnance down the river during the last war, how did you send it, by rail? A. During the Spanish war? I was not here then. I was here twenty years ago, and there was nothing then sent from the wharf, that I know of. The only thing that I ever knew to be received at the wharf were some old guns, which had better been left there than to have been sent. I have a crane running down there for the purpose of delivering coal. There is a dock there that perhaps might be considered —

Q. (by Mr. BAILEY). How long have you been at the arsenal, Colonel? A. I was here twenty years ago, and since then I have completed the grand circle and returned here.

Q. (by Mr. HAMLIN). It would be possible to dredge out the river to almost any depth up to Watertown. A. My only experience in regard to that matter has been perhaps on the Missouri River and on the Mississippi River Commission, of which my son is engineer. I should say the Charles River presented easier opportunities for dredging than any river I know of. It is not necessary for me to listen to that interesting paper which has just been read to be convinced of the possibilities of improvements along the Charles River. I think I have a sufficiently vivid imagination to see the possibilities in that direction. The present valley is certainly unattractive, and it could be greatly beautified; and, as I understand it, the grass slope would obtain where they are necessary, and with the present existing magnificent opportunity for dredging, local opportunities and facilities of the harbor and the great improvement in our machines and the character of the soil, I should think it was the easiest engineering problem any one could desire. I should think you could do almost anything with that valley if you had money enough, but I am going beyond my original line.

Q. (by Mr. DUNBAR). You are expressing here your own personal opinion, are you, or are you expressing the opinion of the ordnance department of which you are a representative? A. No, I am not expressing the opinion of the ordnance department, but only my own personal opinion; and also, as I have stated, my own official recommendation has been presented in my annual report, and it has been included in that portion of the report published by the chief of the ordnance department, — he makes an extract from my report, and forwards it to Congress.

Q. What did your recommendation include, — what plan? A. I had no plan whatever.

Q. What was your recommendation, — was it in regard to the boulevard? A. I made no special recommendation. I said that I was in communication with this commission, and I thought that, if a cession of land was necessary in order to facilitate the carrying out of the plan proposed, I saw no objection to such cession of land by the government.

Q. Did your report contain any plan? A. No, merely a brief reference to the subject; there was no occasion for me to include any plan. I was only in formal communication with the commission, I said that they had sent to me for information.

Q. Then your report contains no recommendation for the construction of a dam either at Craigie's bridge, or West Boston bridge, or anywhere else? A. No, sir; it is out of my province to report anything, only in the most general terms.

Q. And it did not refer to any plan? A. No, sir; only to say that in general terms I am ready to recommend it.

Q. Your report did not make any reference to the dam at all, — or did it? A. No, I think I merely spoke of the commission in general terms, and of the improvement of the river, and referring to the boulevard.

Q. So far as your own views are concerned, what should you say as to the advisability of the construction of a dam at St. Mary's Street, or lower down? A. I should not make a statement on it. Of course the lower you put it, the bigger the body of water. The lower down you place the dam, the longer and larger will be the boulevard and the greater the display, and the bigger would be the scenic effect.

Q. Have you considered any of the other problems connected with this project besides the scenic effect? A. Well, I heard the reference to the possible objections; something has been said with reference to the scouring effect, — that the scouring effect would be lost. Isn't it proposed to allow the dam to have means of letting out the water occasionally?

Q. We don't know. A. If that is so, then that would obviate such objections.

Colonel Butler. I simply was willing to say that personally and officially I was in hearty sympathy with any project that would improve and beautify the Charles River. I understand that my predecessor held opposite views.

That is as far as I go at the present time, although I am ready to say that, if necessary, I think the cession of property might be made by the government, and I should so recommend.

Q. (by Mr. HAMLIN). Colonel Butler, in the ordinary course of events, if application were made to the Secretary of War in regard to the carrying out of this project, would that matter naturally be referred to you? A. It would be referred to me.

Q. As well as to the engineer corps? A. Yes, it would be referred to the engineer department as to the effect it might have on the navigation of the stream; beyond that the engineer department would not be interested, and it would be referred to me for consideration as to the effect it might have on government property.

Q. That is, it would be referred to you for your opinion, as the commandant at the Watertown arsenal, as to the effect that the proposed project might have on government property? A. Yes, sir; as commandant at the Watertown arsenal.

Q. But the engineering problem would be referred to the engineer corps? A. Yes, sir.

F. W. Hodgdon, engineer of the Board of Harbor and Land Commissioners, read the following letter from that Board.

BOSTON, Dec. 19, 1901.

Committee on Charles River Dam, 14 Beacon Street, Boston, Mass.

GENTLEMEN: — The request of your chairman, dated December 16, for "a statement of the condition and the plan adopted for the future development of the public work under your [our] charge so far as it might relate to the question under investigation," is at hand. A complete and comprehensive answer to your question will necessarily be brief.

The amount of public work planned by this Board which could be affected by your determination of the question before you is limited.

1. The Board has no plans with reference to Charles River above Charlestown bridge.

2. The Board has completed the Commonwealth pier on the frontage of the South Boston flats. These flats are shown on a plan transmitted herewith. The project for the improvement of these flats contemplates a series of piers substantially similar to the one shown on plan, extending along the frontage, as thereon appears, the building of which should be regulated by the growth and demands of commerce.

3. On the same plan is delineated the space authorized by the Commonwealth to be dredged to the depth of 30 feet for an anchorage ground. On the north side thereof an embankment is projected, to be protected by suitable bulkheads, at right angles to which piers are to be extended, 400 feet along, at intervals 400 feet apart, for the purpose of

tying up vessels alongside each other when there are too many to be permitted to swing at anchor.

4. The plan further shows the Commonwealth's flats at East Boston, which at some future time are to be developed, presumably in the interests of commerce and navigation, the plans for which, however, are not yet matured.

These are the only public works contemplated by this Board which can be classed as coming within the scope of your inquiry. In addition to the foregoing, however, the Board is accustomed from time to time to dredge in shoal water for the purpose of improving navigation in various parts of the harbor. A list of the dredging hitherto made and the material removed will be forwarded if at any time it should become of interest to your Board.

In 1895 the Board made a report to the Legislature giving information as to certain shoalings in the harbor, which report is herewith transmitted.

For the Board, WOODWARD EMERY,
Chairman.

Q. (by Commissioner DANA). Have you submitted some of the plans to the commission? A. Yes, sir; some of the plans have been submitted, and the other plans are in our possession.

Q. And those plans, or the plans referred to, are going with that report of 1895, — there is nothing newer, is there? A. There is a plan showing Commonwealth flats at South Boston and the anchorage scheme and the East Boston property, as well as the plans annexed to that report.

Q. (by Mr. J. J. STORROW). Mr. Hodgdon, has your office the data in regard to the speed of the currents in the different portions of Boston harbor? A. We never have taken any current measurements except in Charles River between Craigie bridge and West Boston bridge.

Q. You have never taken any measurements to furnish data in regard to the speed of the current in the main ship channel of Boston harbor? A. No. We have the coast survey publications, containing what they have published on that subject.

Q. Have the Harbor and Land Commission ever made any study of the subject with a view to ascertaining measurements on that point? A. We have made no measurements of them.

Q. Is it within your information that in the main ship channel inside of Castle Island, near the lower middle, the resultant of the ebb and flow is an up current? A. We have made no measurements of that at all.

Q. Do you know whether that is shown by the government publications? A. I have never studied the question of currents with any such idea in mind.

Q. What is the policy of the Harbor and Land Commission? What has been done in regard to marsh land, for instance, Soldiers' Field, or that portion of it that has been diked, — has there been any compensation required in such cases as that? A. I do not think the Harbor and Land Commission know anything officially about it.

Q. Have there been any cases where for filling in marsh land compensation has been insisted upon? A. Marsh land is ordinarily above the tide.

Q. I suppose it is ordinarily above the tide? A. Compensation is only charged on the average rise and fall of the tide.

Q. So that is not ordinarily charged on marsh land? A. That is beyond the range of compensation.

Q. Isn't it true that the United States engineers have said that compensation near low tide is valueless? For instance, water that comes from the Charles River and goes into the harbor late in the tide is a detriment rather than a help, — I mean to say that if it meets the incoming tide it delays it? A. I think I have seen that stated in their reports.

Q. Was the dredging that has been done on the Charles River basin of the flats required to be done by the Harbor and Land Commissioners, or was it done voluntarily, with permission? For instance, all that material that has been put behind the Cambridge embankment. A. A certain portion of that, I think.

Colonel MANSFIELD. I think I can explain that. That material is taken out within the lines, and is within the jurisdiction of the war department, and requires permission from the Secretary of War, and I think permission was obtained. I think there was a case in regard to the taking of gravel, where a gravel was found in the river, permission of the Secretary of War was secured for the taking out of gravel. If my memory serves me right, that was done while I was here in charge of the work. The Harbor and Land Commission has no right between the two lines.

Mr. STORROW. May I ask if the Harbor and Land Commission has no jurisdiction over the flats?

Colonel MANSFIELD. I think not, — that is, if the harbor line follows the line of the embankment.

Mr. STORROW. Then the dredging that has taken place there is purely voluntary.

Colonel MANSFIELD. All the dredging outside of the harbor lines must be done under the authority of the Secretary of War.

Mr. STORROW. Between the real line of the river and the flats, — whether that has been compelled, or merely permitted.

Colonel MANSFIELD. That would depend upon where the harbor line is, — if it follows the low water line, or if it goes away back beyond the marshes.

Mr. STORROW. I was taking the specific case opposite, the Cambridge embankment, — that is entirely outside of the marsh land. I was interested to know in regard to that, because there has been considerable dredging done there.

Colonel MANSFIELD. I think you will find the harbor line follows the line of that wall.

Mr. STORROW. Then what I want to get at is, whether that dredging has been directed, or enforced, or permissive.

Colonel MANSFIELD. My recollection is that it has been permissive.

Mr. STORROW. That is not part, then, as I understand it, of any tidal compensation theory or practice of the Harbor and Land Commission.

Colonel MANSFIELD. It is simply this, that no compensation is required. It is taking of material out from between the high and low water lines, and improving the tidal prisms and improving the bottom. It is only when any change is made that compensation is required.

Mr. STORROW. So that while material has been put upon the Cambridge marshes, it has not been considered an encroachment on the tidal prism in any way, — no compensation was exacted for it?

Mr. HODGDON. I do not think they made any payment directly, that is, in cash.

Q. (by Mr. STORROW). Can you define in a general way what has been the practice of the Harbor and Land Commission in regard to these matters? A. Following the statutes.

Q. What does it require? A. You will find that it requires compensation in certain cases.

Q. As a matter of fact, has the city of Cambridge given compensation for the building of that wall? A. I do not think they paid any money.

Commissioner DANA. I think in that particular case there was a statute which authorized the filling in of this that did not require any compensation, — in the case of this Charles River embankment.

Q. (by Mr. STORROW). I should like to know what you

consider the chief cause of trouble with the harbor. Hasn't it been the washings and wearings of the islands in the harbor, rather than material brought down by the Charles River? A. I did not come up here to-day to give opinions; I came to give information in regard to what we were doing in the harbor.

Mr. Louis M. Hastings, city engineer of the city of Cambridge, then read the following report: —

JAN. 14, 1902.

HENRY S. PRITCHETT, Esq., *Chairman, Committee on Charles River Dam.*

DEAR SIR: — I beg to acknowledge receipt of your favor of Dec. 16, 1901, informing me as to the proposed hearings "as to the feasibility and desirability of constructing a dam across Charles River," and requesting "a statement of the present condition and the plan adopted for the future development of the public work under your charge, so far as it might relate to the question under investigation."

I submit the accompanying maps, marked No. 1 and No. 2, as exhibiting some of the physical features of the city and also the works constructed and proposed, which would be more or less directly affected by the proposed dam across the Charles River, together with such data as I have at hand and which may be of interest to the committee.

On Map No. 1 the shaded red line shows the boundary of the territory now draining into Charles River; this includes an area of about 2,655 acres. The shaded brown line shows the boundary of the land originally low, part of which was of a marshy character and part of which was flats, and which has since been largely reclaimed by filling, and is now to a good degree occupied by dwellings, factories, etc. The area of this tract to the present harbor line of the river, including park lands, is about 950 acres. The shaded blue line represents approximately a former shore line of the river, as determined by the edge of the marsh at mean high water. This determination of the shore line is from such old plans as I have examined and from surveys made by the city about the year 1873.

With regard to the sewers of the city, these have been constructed from time to time since the year 1845, until now the total length of sewers in the city is 588,878 feet, or 111.530 miles. The total cost of construction of sewers to 1902 has been $1,561,776.38.

On Map No. 2 the areas discharging through the different outlets are shown by shaded lines, and also the location of the discharging outlets into the river, the location of connections with the State metropolitan sewer, and the position of the regulators where the sewer is a combined one. The areas of these districts are given in red figures, and do not include that of the river parkway opposite.

The following is a statement of some facts concerning these sewers in question: —

Combined Sewers.

LOCATION OF OUTLET.	Size of Sewer.	Elevation at Tide Gate. Bottom.	Elevation at Tide Gate. Top.	Area of Drainage District.	Tide Gates.
Bridge Street, . .	8′ x 8′ 4″	.25	8.25	152.42	Double set barn door gates.
Talbot Street, . .	24″ x 30″	5.00	7.60	87.41	Two sets wooden flap gates.
Binney Street, . .	8′ x 8′ 4″	.79	8.79	833.43	Double set barn door gates.
Pearl Street, . .	32″ x 36″	4.75	7.75	68.95	Single iron flap gate.
Pleasant Street, . .	32″ x 36″	3.75	6.75	88.32	Single wooden flap gate.
Western Avenue, .	42″ x 48″	2.50	6.50	130.09	Double set barn door gates.
Plympton Street, .	48″ x 54″	3.14	7.64	399.50	Single set barn door gates.
Dunster Street, . .	19″ x 24″	9.50	11.50	19.73	Single iron flap.
Murray Street, . .	30″ diam.	5.75	8.25	66.07	Double set iron flap gates.
Bath Street, . .	40″ x 52″	7.33	11.70	234.70	Single wooden flap gate.
Willard Street, . .	24″ x 30″	2.28	4.78	19.58	Single iron flap gate.
Sparks Street, . .	32″ x 41″	6.25	9.70	63.70	Single iron flap gate.
Lowell Street, . .	52″ x 52″	5.50	9.83	295.16	Double set wooden flap gates.

Storm Water Drains.

Greenhalge Street, .	3′4″ x 3′8″	4.80	8.47	52.62	Single wooden flap gate.
Massachusetts Ave.,	18″ diam.	6.00	7.50	-	None.
Robinson Street, .	5′ 8″ x 6′	4.60	10.60	73.07	Single wooden flap gate.

Twelve outlets of combined sewers above Bridge Street, and three outlets of storm water drains.

Total area above Bridge Street (not including Charles River parkway) draining into Charles River, 2,432.33 acres.

Until 1899 practically all the sewers of the city were constructed on the combined system, — *i.e.*, taking both storm water and sewage, — and having their discharging outlets into either Charles River or Alewife Brook. Since the early part of 1897, however, all the sewers have been connected with the State metropolitan sewer, two branches of which pass through the city near the discharging point of the sewers, so that now it is only in times of storm, when the metropolitan sewer is unable to care for the entire flow of mingled storm water and sewage, that discharges into the river take place. The control of the flow of the sewage, whether it shall be into the metropolitan sewer or through the outlets into the river, is maintained by the Metropolitan Water and Sewerage Board by means of apparatus regulating the flow, and placed at the various points where connections are made with the metropolitan sewer. In order to ascertain with some accuracy to what extent this discharge into the river actually took place, automatic registering apparatus have been placed on some of the regulators and tide gates; and the length of time during which the regulators were shut and the length of time that the tide of gates were open, for the three years, 1899, 1900 and 1901, have been fairly well determined.

The following summary shows the results of the records kept by these registers: —

YEAR.	Binney Street Regulator.				Binney Street Tide Gate.				Bath Street Tide Gate.				Massachusetts Avenue, Alewife Brook Regulator.			
	Number of Times shut	Number of Hours shut.		Percentage of Total Time.	Number of Times open	Number of Hours open		Percentage of Total Time.	Number of Times open.	Number of Hours open		Percentage of Total Time.	Number of Times shut.	Number of Hours shut.		Percentage of Total Time.
		hrs.	min.			hrs.	min.			hrs.	min.			hrs.	min.	
1899, . .	73	606	45	6.93	47	246	-	2.83	74	569	-	6.50	-	-	-	-
1900, . .	69	655	15	7.48	43	291	10	3.32	40	316	25	3.60	65	387	8	4.42
1901, . .	54	394	40	4.51	32	217	20	2.48	37	209	-	2.39	36	587	30	6.74
Average,	-	552	13	6.31	-	252	10	2.88		364	30	4.16	-	487	19	5.58

It may be noted that in the case of the Binney Street sewer apparatus the regulator is shut a much longer time than the tide gates are open. This may be largely explained, I think, by the fact that storms often occur at the time of full tide, when the tide gates would be shut until the water in the sewer behind the gates had risen to a level higher than that of the outside; so that for quite a period of time the regulator might be shut at the same time the tide gate was shut, and the mingled storm water and sewage would be simply collecting in the storage room of the sewer, to be discharged when the tide had fallen away sufficiently.

The area of territory which now drains into the Charles River above the Bridge Street outlet is 2,432.33 acres. The population of this area, as near as I can estimate it from the number of polls obtained, is 75,220.

There have been taken by the city of Cambridge for park purposes along the river front some 113.659 acres of land and flats, and about 41.19 acres by the State Metropolitan Park Commission. The total area in the city now held for park purposes by both city and State is 533.274 acres. Of the area held by the city, a considerable portion has been improved. The total frontage or shore line of the river from Craigie bridge to the easterly line of the metropolitan park lands is about 23,900 feet, or 4.52 miles. Part of this frontage has been improved by the construction of sea walls or beaches, and also by filling, generally to grade 16. Of the frontage owned by the city, 9,400 feet, or 1.78 miles, are yet unimproved. None of the front held by the Metropolitan Park Commission has been improved.

Respectfully submitted, L. M. Hastings,
City Engineer.

Q. (by Mr. Dunbar). How high up do you go? A. We only go to Cambridge.

Q. (by Commissioner Dana). That other goes out to Alewife Brook? A. Yes, to Alewife Brook. That red line clearly indicates the boundary of the drainage territory. The shaded brown line indicates the boundary of the marsh.

Each drainage tract has a separate outlet of its own for storm water into the Charles River, the areas of which are shown in the table, and, unless you wish, I will not read those figures at this time. At the present time the Cambridge branch of the metropolitan sewer discharging at Deer Island enters Cambridge at this point here; the other branch coming from the Mystic River branch enters Cambridge here at Alewife Brook, but, as it was not concerned in this inquiry, I have not put it on there.

Mr. Hastings made explanations in regard to certain recording apparatus as follows: The first apparatus was put on at the lower point, which is indicated right at Binney Street, at its junction with Portland Street; one set of apparatus was put there, one at the tide gate out here near the river, another set of apparatus at Bath Street, which is at that point there, and another set was put on this branch at that point there. There were three different sets.

Q. (by Commissioner Dana). The data that you are now going to give us are in reference only to the discharges into Charles River? A. I have got it here. I thought it might be of interest to give it all. Alewife Brook is not directly concerned in this inquiry, but it may be worth while to give it to you for all. I have given here the one for Alewife Brook, at Massachusetts Avenue. Now at Binney Street, in 1899, I found that this Binney Street regulator, which is the lowest one I have referred to, was shut 73 times in the year, — it was shut 606 hours and 45 minutes; in 1900 it was shut 69 times; and in 1901 it was shut 54 times, as you see. I do not know how familiar the committee is with the operation of these regulators. If you desire it, I might explain.

Q. (by the Chairman). I think perhaps you had better explain the operation of the regulators. A. The metropolitan sewer is calculated to take a certain amount of water, or whatever it is, sewage, or storm water it is called in time of storm. Of course the excess of water must go somewhere else. The pumps have a limited capacity, so that in time of storm only a comparatively small amount of sewage and storm water can be taken. The excess of that water must then be discharged through its former outlet. Now, the amount of water they take is controlled and regulated by certain apparatus which is made for that purpose, and that is in the hands of and under the control of the State Board of Water and Sewerage. The city of Cambridge, for instance, builds her sewers and connects them with the

metropolitan sewers, and this apparatus for those sewers is in the control of the State Commission. This apparatus is so arranged that during storms, and when an excess of water over the normal flow occurs, the valves shut, and the surplus overflow then goes into the Charles River. This surplus flow, of course, is mingled storm water and sewage. Now, it was to ascertain how long and to what extent these regulators were shut that I put on this apparatus, this registering apparatus; so that when I say the regulator was shut, it simply means this apparatus had shut off the main sewer's discharge into the metropolitan sewer, and was discharging into the Charles River in its original state.

Q. (by Mr. Bailey). Where are those put in? A. They are built in chambers right at the junction. The floats that regulate them are in chambers in the city sewers.

Q. (by Commissioner Dana). So that it depends upon the height of water in the city sewers, and not on the height of water in the metropolitan system? A. Yes; they depend upon the height of the water in the city sewers, which depends upon the height of the water in the metropolitan sewer. The metropolitan sewer system controls them. We have them built for that purpose. The position of these regulators I have indicated on a small scale on these maps. You can see them on the map at different points scattered along the Charles River. I had a set of regulators put on at different points.

Q. I understood that those are tide gates, and that when you say they are open that means that there is sewage and storm water combined coming out; and that when there is not any sewage and storm water coming out, they are closed by their weight? A. Yes; that is usually the case.

Q. Yes. And when they say they are open, that means that during that time the storm water is passing out? A. Yes, sir; the opening of the gate indicates the movement of the water from the sewer overboard.

Q. This is let out by the stoppage of its going into the metropolitan system? A. Yes, sir; I cannot conceive of any case where the gates would open without movement of the water inside. Of course it is possible that there might be a chip caught in the gate and open it, but that would be an accident rather than a normal condition.

Q. (by Mr. Hamlin). Have you the area in square miles? A. A little more than 3½ miles, — well, nearly 4 miles.

Q. (by Mr. Dana). Mr. Hastings, I would like to ask

you if you would kindly furnish the committee with copies of your engineer's report, — or could your city clerk furnish them? A. For what year? The most interesting ones, I think, would be the reports for the last three years. I should be very happy to do so.

Q. You have spoken of the report of 1901, — is that in print? A. Not yet; no, sir.

Q. 1901 was a very rainy year, and 1900 was rather dry, was it not? A. What?

Q. 1901 was more rainy than the year before? A. I think there was more rain; I think there were about two inches more rain, if I remember the total rightly.

Q. And yet those valves were closed a much shorter time? A. Yes, sir.

Q. Had you thought of any explanation for that? A. No; I cannot explain that, unless the distribution of the rain; of course that has an important effect on the discharge.

Q. Do you think that the new pumps that were put into the metropolitan system doing more pumping would partly explain that? A. That might; yes, sir.

Q. In this report for 1901, had you given the results of that to the metropolitan sewer engineer here? A. I think they copied it; I think so.

Q. I would like to ask one more thing about these regulators. When the tide is high, and there is a storm at the same time, of course the gates are kept closed until the water has risen sufficiently high in the sewers to make the inside pressure stronger than the outside, and open the gate? A. Yes.

Q. As you have explained just now. Now, when that backs up, is there any chance that where those floats are placed in your sewers that those floats are held up and shut on account of the water backing up, of the backing up of the water, or they are too high for that, — if I make that clear? A. Of course the floats rise to a certain point, and then they cannot go any further.

Q. I am not speaking about that. But I had been thinking over one possible explanation for so much discrepancy between the regulator and gate records besides the one which you have mentioned, and which might be very important in ascertaining the amount of discharged water. When there is a storm, and the valves are shut and there happens to be a high tide, and the water backs back, wouldn't it hold up the regulating floats, even after the storm had stopped, for a greater length of time than they

would have been held up if it hadn't been high tide? A. I do not see why it should be.

Q. Wouldn't that keep the floats up? A. Certainly, until the elevation had receded.

Q. What I mean is, that those floats in the chambers where placed are at a level where they would be affected by the backing of the tide? A. Undoubtedly.

Q. Then that might happen, if the storm came at the time when the tide was rising? A. Yes, sir; you can conceive of a situation where a storm might come at a time when the tide was rising.

The CHAIRMAN. Supposing the water in the metropolitan sewer had gone down so that it was prepared to take water from your sewer, but that in the mean time the water had been backed up in the sewer, in the Cambridge sewer, by reason of a flood gate kept closed, — now, whether the water from your sewer would immediately begin to flow into the metropolitan sewer as soon as it was ready to take it. It would, wouldn't it? A. I think not.

Q. (by Mr. DANA). Do the valves shut absolutely tight? A. There are different kinds of mechanisms. One kind, the plug valve, shuts pretty tight; and another kind is where there is a movable joint, where there has always to be a clearance; there are larger movable kinds, with a sliding gate in front of the nozzle, and these leak quite considerably.

Q. Could you give us any idea, even a rough estimate, of how much that leakage amounts to, whether it is one-fourth, say? A. No, I think not.

Q. Or one-eighth? A. The leakage is relatively quite small. But it makes a disturbance in the chamber.

Q. As the valves are placed in the city sewers, and not in the metropolitan sewer, — when there is a pretty good storm and the tide gates are shut, the metropolitan sewer is not taking as much as it might take? A. Of course they can regulate their valves so as to take a little more in one, or a little less; that they have in their own hand.

Q. Do you know anything about these special regulations in the particular sewers on which you have made these experiments? They are subject to change from time to time, as I understand it? A. Yes.

Q. Are you sure that the regulations that they have made on these valves in the particular sewers where you have tried your experiments were the average regulations? A. I think they are. As I understand it, we have three sewers where we have what I call a high regulation, where they

don't shut at all, — that is, where we have extremely high, unusually high regulation.

Q. You have never put your clocks on those regulators? A. No.

Q. And these are not shut? A. No; we don't calculate that they will ever be shut; we hope they will never be shut. This portion here that is shaded blue I meant to speak of in my statement. The territory covered by these separate sewers is indicated by these blue lines, and is cross-hatched in there in blue.

Q. I don't understand. That is only the separate sewer system. A. Yes, sir.

Q. That is all right. In the separate sewer system, — you have already begun that in Cambridge, and that map numbered 2 indicates the portions with blue coloring, where you have the separate system? A. Yes, sir.

Q. I would like to know whether or not you mean to extend the separate system by degrees, as the city of Cambridge can afford it? A. Well, I cannot tell what the city will do; I can only say we have made a beginning.

Q. You have made a beginning? A. Yes, sir.

Q. Have you ever made any recommendation on that? A. Yes, sir.

Q. What is your recommendation? A. In 1898, I made a report recommending that.

Q. Recommending the adoption of the separate system? A. Yes, sir.

Q. As far as possible? A. Yes, sir.

Q. And as to the part that you have already operated, as separate system, does that operate satisfactorily? A. Yes, sir.

Q. But to adopt it suddenly for the whole city of Cambridge would be a very great expense, would it not? A. Yes, sir.

Q. Do you know about how much it would cost to adopt it for the rest of the city? A. No, sir.

Q. It would be almost a reduplication, wouldn't it? A. You would have to have another system.

Q. Almost as large as the present one? A. Fully as large.

Q. (by Colonel MANSFIELD). Would it be as expensive? A. No, it would not be as expensive; it would not be as large.

Q. (by Commissioner DANA). You would use the present system for storms? A. Yes, sir.

Q. The new system would be as long, but the pipes

would be smaller? A. Yes, sir. As long, but they would be smaller, — deeper, perhaps.

Q. (by the CHAIRMAN). Then your reply would be that, if a dam were built on Charles River as far down as has been proposed, and that thereby water was held at a constant level, that fact would mean that some way must be provided for getting rid of the sewage which comes through Cambridge; and that means approximately that during 550 hours, sewage, combined storm water and sewage, must be taken care of? A. Yes.

Q. That would be the problem? That does not give us what proportion of the total discharge that would be? A. It would be very difficult to give anything that would be reliable.

Q. Which only means that during about 6 per cent. of the time there is some discharge? A. Yes, sir.

Q. (by Mr. DANA). During the last year, while they have had new engines pumping in the metropolitan system, what was the per cent. of time then? Did you give the per cent. of time, as well as the hours? A. Yes; you have it there; 4.51, isn't it?

Q. The last year, since they have had the extra pumping engines in the north metropolitan system, the per cent. has been 4.51 of time, while average per cent. was 6.31. Let me ask this: which has the largest outflow in Cambridge of any one of those sewers? A. The Binney Street.

Q. How far is the mouth of that from Craigie bridge, roughly speaking? A. Two thousand feet, I think; it is just about 2,000 feet.

Q. That is considerably larger than any other single sewer, isn't it? A. Yes, sir; that has got the largest outlet.

Q. Have you ever considered whether it would be possible, if a special sewer was taken from the mouth of that drain, and carried down below Craigie bridge, — whether it would be possible for the metropolitan system to pump nearly all the rest of the system until you got it separated? A. I could not say as to that, because I am not familiar enough with their pumping capacity nor the capacity of their sewer. That would be a matter that would have to be investigated before it could be answered definitely.

Q. Have you ever, from the size of the sewer, or any other data, calculated what proportion of the total drainage goes out at the Binney Street outlet? A. There is a population of 75,000 on the whole area. I don't know what the population is of the Binney Street district alone; but it could be ascertained.

Q. There is the size of the drainage and the area of the district also to be taken into consideration. It would be a difficult thing to ascertain, would it? A. Oh, no. The total area is 2,400 acres, and the Binney Street district is 833 acres, — about one-third of the total area; but that does not necessarily follow that it would be one-third of the population.

Q. But it would indicate that it would probably have one-third of the storm water? A. Yes, it would probably have one-third of the storm water.

Q. That one-third could be taken care of by a separate connection covering those 2,000 feet? A. Yes, sir.

Q. How large a sewer would you have to have for that? Did you give the size of the Binney Street sewer? A. Yes, sir; 8 feet in diameter; it would have to be certainly as large as that.

Q. And they would probably have to put a syphon under the canal? A. Yes, sir; they would have to go and syphon under the canal.

Q. (by Mr. MATTHEWS). Mr. Hastings, I would like to inquire whether the separate system you are introducing will be introduced in the whole system, or only in the newer portion of the city? A. Of course I cannot tell what future city governments will do.

Q. Your recommendation, as I understand it, was to substitute the separate system in the older portions of the city? A. Yes, sir; in 1898.

Q. And some action has been taken in that regard? A. Yes, sir; we have made a beginning.

Q. And some money has been spent for that purpose? A. Yes, sir.

Q. Have you anything to show how much has been spent in that way? A. Well, I think about $250,000.

Q. In the procurement of the separate system? A. Yes, somewhere from $200,000 to $250,000.

Q. Have you any statistics or data which would enable you to estimate the percentage of the flow or overflow from the sewers into the river? You have given us figures which indicate the duration in time, but have you any figures on which you can estimate the flow? A. The volume? No, sir.

Q. Either of the flow itself, or into the river? A. No, sir.

Q. You could not get that from any available data? A. No, sir.

Q. It is true, is it not, that the first effect of a rain storm is to wash into the metropolitan sewer? A. Yes, sir.

Q. So that what flows out into the river is sewage in an extremely diluted condition, isn't it? A. Yes, sir.

Q. (by Mr. DANA). Then, in the separate system of storm sewer and house sewer what would be their proportional areas? A. That is a very difficult question to answer. The size of the sewer is according to the area and the slope of the land — the size of the house sewer draining the sanitary district would be in proportion to population.

Q. I was thinking whether we could gain anything to show the proportion of sewage and storm water. A. I do not see how I can answer that.

Q. The storm water is considerably more? A. Oh, yes; the amount of the sewage would be merely a drop in the bucket.

Q. I wanted to show the proportion when they got pretty full. Would the sewage be one-quarter or one-tenth? A. I don't think it would be as large a proportion as that.

Q. (by Mr. MATTHEWS). Wouldn't it be one per cent., in your opinion, more nearly?

Q. (by the CHAIRMAN). It seems very difficult to form an opinion. A. I could not.

Q. (by Commissioner DANA). You could give limits, perhaps, between one per cent. and some other per cent. A. We could take it on an estimate of the population that would yield in a year a certain amount of sewage, and in a year at 45 inches average rainfall you would have a certain amount of storm water; you could get a proportion in that way.

Q. No, because that would only give it for the year. We wanted to get it when the sewer was discharging into Charles River. Relatively there is very much difference. A. Yes, between the house sewage and overflow storms.

Q. (by Mr. DUNBAR). Are there any low lands in Cambridge that would be affected by the maintenance of water at a permanent level, say at grade 8. A. Well, we have a large tract of low land there.

Q. How large? A. As I stated, about 950 acres.

Q. How would it be affected? A. I don't know.

Q. You have never made any survey? A. No.

Q. (by Commissioner DANA). If it is maintained at grade 8, would there be any difficulty in the storm water going out? A. Through the land?

Q. No, I am not speaking of through the land, but through the sewers. A. No, sir; I don't think so.

Q. You couldn't get at the sewers so easily to clean them as you can now; but that is a difficulty which could easily be remedied. A. It would need some apparatus.

Q. (by Mr. MATTHEWS). Where is the water level now in this low area you spoke of? A. It varies, but I have really never made any borings to ascertain this, — where the level was.

Q. (by Mr. DUNBAR). Can you tell us about what the average grade of the low land is? A. It has been filled now largely to grade 13. The line is grade 13, and the streets are grade 16, almost universally.

Q. It is not all filled? A. No, not all, but largely.

Q. Will it all be filled in time? A. I presume it will in time.

Q. (by Commissioner DANA). Grade 13, — that is Boston grade? A. Yes, sir; Boston grade 13.

Q. Is that Boston base? A. Yes, sir; Boston base.

Q. (by Mr. DUNBAR). Are there any flats now exposed along the river? A. Yes, there are some near the Cambridge bridge.

Q. These are all included in park takings? A. No, I thought you meant flats; flats are filled in behind the sea wall.

Q. (by Commissioner DANA). There are some flats exposed outside of the sea wall? A. Yes, sir; some outside, near the West Boston bridge.

Q. (by Mr. DUNBAR). Anywhere else? A. On Boston side there are a good many.

Q. On Cambridge side? A. We have stripped them all pretty well.

Q. Can you tell us what area of flats have been stripped there? A. No, I cannot; I have not looked that up.

Q. (by Mr. PILLSBURY). How far above Craigie bridge is Binney Street outlet? A. Two thousand feet.

Q. (by Mr. BAILEY). I should like to ask about the way sewage flows from one system to the other, — whether that flow keeps the valve open all the time, or not? A. Yes.

Q. Is the valve regulated by the flow in the metropolitan sewer? A. No, sir.

Q. Are you sure? A. Not in our sewer. The float is in the chamber in the city sewer.

Mr. BAILEY. I wish you would look that up, and see.

Q. (by Mr. DANA). You have been down there yourself, Mr. Hastings, and you know what they are? A. Yes; they connect.

Q. (by Mr. BAILEY). Isn't the theory that as long as there is room, and as long as the flow is comparatively small, it takes the flow all right; but when it fills up it

checks and shuts the valve, and then flows out, therefore the float is in the metropolitan?

Q. (by the CHAIRMAN). Ought not that to be the arrangement? It would seem to be. A. The floats are all in the city of Cambridge sewer.

Q. That would seem to be a very singular arrangement? A. Yes, sir.

Q. (by Mr. BAILEY). Do I understand you to say that the length of time of overflow is indicated by the length of time that the tide gates are open? A. Yes; of course the water cannot flow out when the tide gates are shut.

Q. (by Commissioner DANA). Are there any of your reports that happen to have section drawings of connections between your sewers and the metropolitan sewer? A. I had one report that shows that. I don't think it goes quite as far as the metropolitan sewer; but if it does, I will forward it to you. The regulator and float are on the city sewer, but there is a small pipe connection which flows into the metropolitan.

Q. What is that for? A. That is to let the water from the metropolitan sewer go into the flood chamber, — usually a small 6-inch pipe.

Q. From the metropolitan sewer into the float chamber? A. Yes, sir.

Q. (by the CHAIRMAN). Isn't it the metropolitan float chamber, then, which fills —

Q. (by Mr. BAILEY). That operates the float, then, doesn't it? A. It does.

Q. Then it is operated by the water from the metropolitan sewer? A. Yes.

Q. (by Commissioner DANA). About what level is this chamber relatively to the metropolitan sewer? A. Oh, the chamber might be on the level, of course, with the metropolitan sewer.

Q. Does the water also from the city sewer fill into this chamber? A. Yes, it passes right through it.

The CHAIRMAN. That is a matter of detail which, I think, we will do well to address later to Mr. Hastings.

Q. (by Mr. MATTHEWS). Are there any private sewers draining into the river on the Cambridge side, or any direct sewage draining directly into the river? A. There may be a few private connections; that I don't know. I can say it is possible, but very few; I don't know of any.

Q. The policy of the city is to take them out, isn't it? A. Certainly; yes, sir.

Q. You said about damage from tides backing up, —

damage from high tides? A. I don't think I said anything about it.

Q. About the effect of high tides backing up against the gates? What has been your experience in that matter? A. In regard to tide gates?

Q. Yes. A. I don't think I mentioned it.

Q. (by Commissioner DANA). Have you had any trouble in Cambridge when a heavy storm has occurred at high tide, backing up, filling of cellars and so forth? A. Yes, sir; we have had.

Q. How serious has that been? A. We have had quite a good many complaints of that sort.

Q. And when it does back up, it is mostly the combined sewage, isn't it? A. Yes, sir.

Q. (by Mr. MATTHEWS). I didn't mean money or financial damage. I understood you to say something of the interference of the city sewage by the backing up of tides, just as you said a moment ago in response to Mr. Dana. A. Unless you refer to the time when the high tide was in.

Q. Yes, exactly. Now, what are those tides, the height and so forth, which make trouble? A. When the tide is high, of course the sewage cannot flow out, and at that time sewage rises in the sewer behind the gates; if at that time occurs a heavy rain, the sewage sometimes backs into the cellars.

Q. That is so, as I understand you, if trouble occurs at periods of high tide; and if the high tide was coincident with the storm, there is still more trouble? A. That might be; yes, sir.

Q. You refer to extreme high tide? A. We refer to extreme high tide.

Q. (by Commissioner DANA). Would the tide have to be higher than the mean high tide to cause this trouble? A. Yes, sir; because some of our cellars are placed above mean high tide, so that if we had it at mean high tide it would not affect them. Usually, our cellars, — it would not affect usually our cellars; but if we had an extremely high tide there, of 3½ or 4 feet, it would be dangerous to cellars.

Q. (by Mr. MATTHEWS). That condition exists sometimes at grade 15 or 14? A. Yes, sir; we have had 14½.

Mr. DABNEY. Not since Minot's Ledge.

Q. (by Mr. MATTHEWS). What do you say has been the tide? A. You mean the average tide?

Q. No; Mr. Dabney says there has not been any grade 15 since Minot's Ledge. A. Yes, sir; I think there have been a few at 15.

Q. And 14 or 13 are common? A. Yes, sir; common.

Q. When do you experience those troubles? A. Usually spring tides.

Q. That is, when the tides are considerably above ten? A. Yes.

Q. (by Commissioner DANA). Of course as far as that goes, if we had a constant level at 8 or 9 grade, that trouble would not be likely to occur, would it? A. No, sir; that would relieve it.

Q. (by Mr. MATTHEWS). You said something about a certain area of water from which you thought drainage never got into the river, — that it was entirely taken care of by the metropolitan system? A. Yes, sir.

Q. Will you indicate that on the map? A. That is the portion indicated in the lower dark blue.

Q. What is that area that Mr. Dana has called your attention to? A. The area sewered on the separate systems.

Q. Then, if I understand you, the area shaded dark purple would give no trouble with reference to the introduction of sewage water into the river? A. No, sir; that's all right.

Q. The metropolitan system would take care of that all the time? A. Yes, sir.

Q. Then there must be still another portion of Cambridge in regard to which the metropolitan system is able to take care of storm water most of the time? A. I don't think they calculate to take care of storm water.

Q. There must be another area in which the trouble or difficulty from admixture of sewage and storm water would be minimized, — or haven't you worked that out? A. I have not worked that out.

Q. You said that the brown indicated the original shore? A. No, the blue line indicates the shore.

Q. What did you say was the brown line? A. That is the line between hard and soft ground.

Q. The line between hard and soft ground? A. Yes.

Q. As of what date is this blue line? A. That blue line is largely from dates prior to 1873.

Q. And represents the condition of the littoral at that time? A. Yes, sir.

Q. Had there not been some filling done in that part at that time? A. I think not; I would not say not at all, because I think there were one or two wharves on Main Street which had been filled.

Q. Substantially speaking, you think that line represents substantially the original line? A. Yes, sir; I think it rep-

resents substantially the original line. There has been some accretions here, I think.

Q. Can you give us the figures representing the amount of river fronts which have been made, proportionally? Can you give us the amount of river front that has been provided with wharves? A. That has been given in my report.

Q. From the calculations you have made? A. Yes, sir.

Q. That is, the whole line of public ownership is given, and the whole line of private wharves? A. Yes, sir.

Q. To what extent are you troubled by the overflow from these sewers at high tide now? A. That is a very uncertain quantity, because it varies with the season. When we have a season, as we did three years ago, of sudden rains, we are troubled a great deal, but last year, although we had a good deal of rainfall, the rain was so distributed that it gave us but very little trouble.

Q. Is there any official publication which gives us any official information in regard to flooded cellars? A. Only in a general way. You mean in regard to number and so forth?

Q. Yes. A. No, sir; I think not.

Q. Have you ever referred to the subject in your report? A. Yes, sir.

Q. Which one? A. In the report for 1897 or 1898.

Q. You mean the report for the year 1897 or 1898? A. Yes, sir; there was a special report made on the sewage of Cambridge, and it appears in that, in 1898, I think.

Q. (by Commissioner Dana). One other fact I want to ask about, unless it is already stated. In the report for 1901, for the regulators, what period did that cover, — up to December 1, or when? A. Well, I should have said perhaps that those periods, these data, are to December 1 of the year to which they are given, — our fiscal year; and reports are all made to December.

Q. That is twelve months? A. Yes, sir; but not in January.

Hearing then adjourned until Thursday, Jan. 16, 1902.

FOURTH HEARING.

STATE HOUSE, Jan. 16, 1902.

The hearing was begun at 10 A.M., Chairman Pritchett presiding.

Mr. DUNBAR. Mr. Hastings, if you please, I would like to ask you a few questions connected with your report. With your report presented yesterday is a table giving the names of sewers and other data. You spoke yesterday of three sewers that were connected with the metropolitan system, upon which you had gauges set. If I understood you correctly, at the time of the overflow they discharge into the Charles River. Is it true that all in this list discharge for about 600 hours a year into the Charles River at the time of overflow? A. Well, of course that is an inference; I cannot say that. Our apparatus were only placed on those three I mentioned.

Q. Have you any reason to consider that the conditions are essentially different in this respect from the others? A. No.

Q. The population is approximately about 72,000? A. No; about 75,200, I think it was estimated from the polls.

Mr. DUNBAR. That is near enough.

Q. (by Mr. MATTHEWS). What would be the population of that area, the sewage of which would be taken care of by the metropolitan sewers? A. I don't think I understand you.

Q. You stated that the surface flow, storm overflow, of some portion of this area would, in your judgment, be taken care of by the metropolitan sewers any way. Now, what would be the population of the rest of that area, the population of the whole of which is 75,000 people? A. Well, the whole area draining into the Charles River is now taken care of by the metropolitan sewer, and on that tract of 2,400 acres is that whole population of 75,000 people.

Q. What is the population of the area on your map which is shaded blue, or purplish blue, — I refer to the area on the right-hand side of the map. A. I have not got that; it would be very difficult to obtain that.

Q. You don't know what that is? A. No, I do not.

Q. (by Mr. DUNBAR). The plan is drawn to a scale, I suppose? A. Yes, sir.

Q. I suppose it could be estimated approximately? A. Well, you see the population would be very uncertain. A part of that is very sparsely populated.

Q. (by Mr. MATTHEWS). Along the river? A. Yes, sir; but if you get here, this part over here, of course, is pretty nearly covered.

Q. (by Mr. DUNBAR). I would like that stated, so that it can get into the record. A. There is a portion on the westerly part of this area that is densely populated — tenement houses and such; the easterly portion of it, on the side of the railroad and the river, between the railroad and the river, is practically vacant.

Q. Then the larger portion of the area which is served by the separate system is very thinly populated, compared with the rest of the system? A. Yes, sir; now.

Q. (by Mr. MATTHEWS). Is there any way in which you could have an estimate of the population of that district prepared? A. I don't see how I could.

Q. You based your estimate on the whole population — 75,000 — for the district? A. Yes, sir.

Q. Could you go over it and make an estimate of the population that is served by the separate districts? A. It might be possible to go over it, to go to each house and to each street and estimate the polls. Whether that could be done by each precinct or ward I do not know, but I suppose it could be done.

Q. How much will that area be increased in the next five years? A. I could hardly say that.

Q. You have spent $250,000 on the separate system so far? A. Yes, sir.

Q. Is that entirely devoted to this area? A. No, because we have over here built a sewer on this portion of the city, near Alewife Brook.

Q. That is the other way. That was not shown on this plan. A. That was not shown on this plan.

Q. Could you give us an idea of what the cost of the separate system has been for the area shaded blue on this plan? A. Yes, sir.

Q. You can give us that? Not now, I suppose? A. I have not the figures with me now.

Q. Will you send them to the committee? A. Yes, sir.

Q. (by Commissioner DANA). I believe you said you had brought some sketches and sections of the tide gates and shut-offs? A. Yes, sir.

Q. Would you produce those, and explain them? [Witness did so.]

Q. (by the CHAIRMAN). Those are the drawings and the chambers? A. Yes, sir; those are the drawings showing the different style of tide gates in that schedule I gave you yesterday; there were references to the different kinds of tide gates, and I thought it might be of service to show you. The one on the left of the plan, being what we call the barn door style gate, opening outwards; these are the wooden floating gates, hung on a long hinge, very sensitive, made of a wooden disc right in front of the sewer; and this at your right being a cast-iron flat gate hung in very much the same manner.

Q. Now, would you kindly show us the other diagram? A. Yes, sir; this diagram shows the general style of the largest-sized apparatus, or regulator, this being a ground plan of it and that being a vertical section right through the section.

Q. The ground plan on top and the vertical section below? A. Yes, sir; the city sewer comes down from your right, — the right side of the plan; the city sewer enters and passes through, — that passes through a sand catcher or sump, as we call it. It is to retain the solid matter, gravel or sand, or whatever may get in there as it passes through. This is a nozzle through which the sewage flows. In front of the nozzle is a tank containing a float. Now, that is connected with a swivel gate on the front of it, and that, as the water rises and falls, of course goes with it. That operates this swivel gate in front of the nozzle, rising or falling as it floats. Our city sewer passes right through. The metropolitan sewer is there.

Q. At the left-hand corner? A. Yes, to your left.

Q. Now, then, the question was raised yesterday whether a storm might not occur on a rising tide, and you would fill this sewer and the flow might not be able to get away as readily as it would on a falling tide. A. I talked with our superintendent of sewers about that, who has charge of that apparatus, and he thinks that in the main that would be so, — that there are occasions and times when the regulator would be shut at those times longer than it otherwise would if the tide was falling.

Q. And longer than it would be necessary for the protection of the metropolitan sewers? A. Yes, sir; he thinks practically that is so. Theoretically I presume this is regulated by the height of the water in here in the metropolitan sewer; but his opinion is that, as a practical thing, there are

times when the water is retained somewhat in the city sewers and is shut longer at certain stages of the tide than at other tides, or at other tides with certain rainfalls. That was your question, I understand.

Q. Yes, sir. Now, I would like to ask, is the connection between the metropolitan sewer and the tanks in which the float works, — is that shown on this plan? A. These are openings — ports made right in there that are not shown, so that the water flows into this tank here according as it rises or falls in the chamber itself. There are four ports.

Q. On the four sides of the tank? A. Yes, sir.

Q. In which the float works? A. Yes, sir.

Q. (by Mr. DUNBAR). You spoke of the water being retained there at certain stages of the tide longer than would be expected theoretically. That is due, of course, to the pressure of the tide on the tide gates? A. Yes, sir.

Q. Which is in excess of the pressure of the sewer? A. Yes, sir; partly that, and partly because this mechanism is not perfect, and it holds the water here somewhat longer than it would if the pressure were relieved.

Q. Would it be true also, that, if the permanent grade of water were raised in the river, there would be the same effect? A. Then there would be no low tide effect.

Q. It would be a similar effect, then, to some extent? A. Yes, sir.

Q. (by Commissioner DANA). This effect we are speaking of happens when the tide is as low as grade 8? A. Well, I could not say the exact point at which this effect would be felt, but we find that in the time of storms at an incoming tide that was the usual time; that if the storm ceases, say, at high tide, we do not get the relief until the tide begins to fall away, as a practical thing.

Q. Did you ever notice at what stage of the tide you begin to be relieved of this pressure? A. No, I don't know.

Q. Do you think your superintendent could tell that, or find that later? A. I doubt that, whether he could tell that point or not; that was a new point that we never observed.

Q. Do you think that in the course of the next month you could tell? A. We might be able to, and we might not; I could not tell. We might not have a storm come at that tide. We have got to have a storm coming on at a rising tide, and then have the storm cease before the tide turns.

Q. (by the CHAIRMAN). Under ordinary conditions of storm and rainfall, would you? A. You have got to take

the natural conditions just right to determine that point; that might take time.

Q. (by Commissioner DANA). What is the height of Cambridge sewers? A. Those are given in that table, the elevation, both at the bottom and at the top.

Q. (by Mr. MATTHEWS). Judge Dunbar asked you something about an average number of hours, 600 per annum. That was for the Binney Street sewer in the year 1899, was it not? A. Yes, sir.

Q. And that was reduced in 1901 after the sewage pump began to pump, — reduced to 394 hours in 1901? A. Yes, sir.

Q. You have the data which show 54 times and 394 hours during which the gate was shut, have you not? A. What do you mean, the original data? I haven't here; no, sir.

Q. You have had it some time? A. Oh, yes, sir.

Q. So that this data would indicate at what time those tides occurred? A. Oh, yes, sir.

Q. Would you furnish this data for all those observations, so that we can tell at what time of the year those overflows occurred? A. Why, I should do it, if the committee wish; it means going over all the records. You can send somebody over there, if you wish.

Q. Well, perhaps we will do that. They will be at our disposal, will they? A. Yes, sir.

Q. What do I understand is the meaning of the area shaded pink? A. That is the area of the water-shed of the Binney Street sewer district.

Q. That is, the area in the shaded pink is the water-shed of the Binney Street district? A. Yes, sir.

Q. What is the population of that district? A. The individual population? I do not know.

Q. I didn't know whether it was explained the other day, or not.

Commissioner DANA. It was explained that it was very dense.

Q. I didn't know whether it was explained, or not, — what this pink shading meant. Will you explain why the separate system as indicated by the blue shadings on this map was put in so irregularly, and not concentrated in one district? A. It seems a little absurd to do it that way, but we took the districts where it was needed most, where we had the most difficulty, and we put it in as you see. That is why it has been done in so comparatively an erratic manner, in the putting in the separate system.

Q. Mr. Pillsbury calls my attention to the fact that you

may have misunderstood my question. Do I understand that the whole of this area shaded pink is tributary to the Binney Street outlet? A. Yes, sir. The Binney Street sewer begins there and runs to there, — you can see the red line indicating where it comes out.

Q. What is the size of that? A. The size of the Binney Street sewer is 8 feet high and 8 feet 4 inches wide.

Q. Do you know what is the area of the territory tributary to Binney Street sewer? A. It is marked 833 acres.

Q. And have you the area — A. Yes, sir. The areas are all indicated there.

Q. And also the area of the blue part? A. Yes, I think it is.

Q. 125.7 acres? A. Yes, sir.

Q. Does that include the regular factors lying to the north-west? A. It includes only this part here.

Q. The other two patches are included in the 833 acres? A. Yes, sir.

Q. Have you any means of ascertaining what the population tributary to the Binney Street outlet would be? Could that be done by the precinct book? A. I think it could; I am not sure of that, — how the assessors have arranged their book. I think it could be done with some approximation.

Q. The two areas together, the separate and the Binney Street, would together comprise a large portion of the Cambridge population, wouldn't it? A. It would be a large part, certainly.

Q. You think that could be ascertained approximately, by using the assessors' books? A. I think so; in part, certainly. I am inclined to think so.

Q. (by Mr. Abbott). The time during which the storm overflow discharges into the Charles River is indicated by the times during which the gates are open, and not during the times which the regulators are shut, isn't it? A. The exact time of the overflow is indicated by the tide gates; the gauge of the amount might be better ascertained by the shutting of the regulator.

Q. (by Mr. Dunbar). There is one thing which you said in reply to my Brother Matthews, which I did not understand, or I understood you to assent to it. There was something about this change in the number of hours occurring after the metropolitan system began to pump. Has that got anything to do with it? A. I understood him to mean that the metropolitan system had increased their pumping capacity; they have added a new pump.

Q. Does that make the difference between the number of

hours, — the 394 hours and the 600 hours? A. I would not say that; I think it might have some effect on it. I think one of the commissioners asked that; that may or may not.

Q. The difference is chiefly due to the manner in which the rain comes, the manner of the rainfall? A. That has a great effect upon it.

Q. (by Mr. MATTHEWS). And you think the extra pumping of the metropolitan sewer might have some effect upon it also? A. Yes, of course if they did not pump at all it would be so all the time.

Mr. Irving T. Farnham, city engineer of the city of Newton, then submitted the following report: —

CITY HALL, WEST NEWTON, MASS., Jan. 14, 1902.

Dr. HENRY S. PRITCHETT, *Chairman, Committee on Charles River Dam, 14 Beacon Street, Boston.*

DEAR SIR: — In answer to your communication of Dec. 16, 1901, asking for plans and statistics of existing or contemplated works in Newton which might be affected by the proposed Charles River dam, I submit herewith a lithographic plan of the city of Newton, showing sewers built and the connections with the south metropolitan sewer.

The city of Newton, located at the upper end of this proposed basin, has a frontage of but 3,800 feet thereon; this is the frontage of a narrow strip running out to the river between Watertown and the city of Boston. All this frontage is controlled by the Metropolitan Park Commission, and the eastern half adjacent to the Boston & Albany Railroad embankment is unoccupied marsh land, approximately at grade 11 above mean low water.

The city of Newton is sewered on the separate system, and the sewers have been designed and constructed to exclude all storm water from the sewers carrying house drainage, the storm water being collected and discharged through the various brook courses into the Charles River. One of these brooks, namely, Hyde Brook, now discharges into the upper end of the proposed basin at grade 10.80.

The sewers conveying house drainage, with the exception of an area of 203 acres discharging through Brookline and 262 acres discharging through the city of Boston, discharge into the south metropolitan low-level sewer, which runs along the south bank of the Charles River to the Waltham line. Sewers are now connected with this trunk sewer at six points, as follows: —

CONNECTION AT —	Grade of Metropolitan.	Size of Sewer.	Grade and Size of Inlet.		Grade and Size of Overflow.	
Charlesbank Road,	6.85	8″	10″	10.71	No overflow.	
Hyde Brook,	7.46	21″	24″	9.86	12″	20.00
California Street,	9.29	8″	10″	12.00	No overflow.	
Crescent Street,	9.65	24″ x 36″	24″	111.61	24″	21.75
Dalby Street,	15.77	12″	10″	18.40	No overflow.	
Cheese Cake Brook,	18.38	24″ x 36″	24″	19.35	20″	23.25

These connections take the drainage of an area of 5,300 acres, with an estimated population of 23,000, or about 30 per cent. of the capacity of the present connections with the metropolitan sewer.

Although the area now served by the metropolitan outlet is much less than eventually will be tributary thereto, the sewer, by backing up from the combined systems below Newton, has discharged at St. Mary's Street about one-third of the time, and has at times backed up and become surcharged through Newton.

Without knowledge of what the proposed dam may be, I give these facts as having a possible bearing upon the question under consideration. Should you in the future require any additional information concerning the works in Newton, I shall be glad to furnish the committee with the same.

Very respectfully yours, IRVING T. FARNHAM,
City Engineer.

Mr. FARNHAM. I will say that the population is estimated from the polls.

Q. (by Commissioner DANA). I would like to ask about the storm water, about the drains. Are they pretty well furnished with catch-basins before the storm water gets into the river? A. Yes, sir; they are. All the connections in the storm water drains are made by means of catch-basins with settling sumps.

Q. (by the CHAIRMAN). That takes out the solid matter? A. Yes, sir.

Q. (by Commissioner DANA). Do you happen to have any statement in any of your reports of the amount of material taken out from those catch-basins? A. No, sir; I have not.

Q. (by Mr. SLOCUM). Perhaps you could state to what extent they are kept cleaned out? A. Well, that is a matter which is in charge of the superintendent of streets; but he has a man going over them all the time after a storm, and we do not intend to have them get clogged up or full, so that there will be any silt get into the drainage.

Q. (by the CHAIRMAN). The discharge is at about grade 8, I understand you to say? A. At this one brook; yes, sir.

Q. (by Mr. DUNBAR). Is that brook the one that runs to the north of your main street sewer in West Newton? A. No; Hyde Brook discharges through Newton and Newton Corner, but it is covered to the main part of the village, and you would not see it.

Q. Where does Cheese Cake Brook enter? A. That opens — we have the entire city under the separate system; there is no house drainage discharges into the brook.

Q. (by Mr. SLOCUM). Can you give the corner where the Hyde Brook empties into the river? A. I cannot indi-

cate it on this map. I think that is the point here on the map. Hyde Brook discharges at the upper end, at that strip about at that point near Charlesbank road [indicating on the map].

Q. (by Mr. MATTHEWS). Where do you get your statistics as to the sewer backing up about one-third of the time? A. That one-third of the time refers to St. Mary's Street sewer. That is a statement in the letter that came from the report of the city engineer for 1898; and I conferred with Mr. Brown, the chief engineer of the Sewerage Commission, and he said that during that year the sewers did overflow on about 120 days. He thought that the conditions were better now than they were at that time.

Q. And when the high-level sewer is completed, that percentage will be reduced to almost nothing? A. I couldn't say about that, sir.

Q. Have you talked with Mr. Brown about it, — won't it be reduced to 3 per cent., or less than that? A. I don't know; it would depend entirely on their pumping.

Q. Do you rely entirely on Mr. Brown in that statement? A. Yes, sir.

MR. HASTINGS — *recalled.*

Q. (by Mr. DANA). Mr. Hastings, would you kindly explain about the catch-basins in Cambridge, for the wash from the streets. Is Cambridge well supplied or is it not well supplied with catch-basins? A. Yes, sir; we have a very large number of them.

Q. And those are kept well cleaned out? A. We have two or three gangs of men with apparatus going about the city all the time, taking out about five or six thousand loads, I think, every year.

Q. How much? A. About five or six thousand loads every year.

The CHAIRMAN. We should be very glad now to have a statement from the city engineer of Boston. I have had put up here the map which came from the engineer's department, showing certain information.

Mr. JACKSON. I will say that that map came from the sewer department. Mr. E. S. Dorr, assistant engineer of the sewer division, street department, is here, and perhaps he can give you more first-hand information than I can. This is Eliot C. Clarke's report of the main drainage in the city of Boston in 1885.

Q. (by the CHAIRMAN). This gives us a statement of

the drainage in the city of Boston? A. That is substantially the conditions as they exist to-day, as far as the Charles River basin is concerned.

Mr. Dorr. This is one of two maps prepared for the use of the commission, and this one showing the matter in detail. The other was simply designed to show the general proportions of the sewered territory compared to the whole water-shed of Charles River. This blue area shows the whole above this point, 315 miles. Those two darker portions show the portions of the water-shed already sewered, the darkest showing that sewered on the combined system and the dark blue that sewered on the separate system. The only object of that is to give the commission an idea how much territory is sewered and how much is still in an unsewered condition.

This map here shows the lower portion of Charles River water-shed with sewered and unsewered territory, the territory sewered upon the combined system being shown by the brown tint and that sewered on the separate system by the blue tint as shown on the other map. The heavy black lines show the water-shed of Charles River as far as it is included in the limit of this map. The smaller next heaviest lines show the water-sheds of Muddy River and of Stony Brook, both of which are comprised within the Charles River water-shed. Then through the Boston territory the subdivisions are shown by still smaller lines, as shown by the pointer. The red line, the solid red line, shows the Boston main drainage sewer, the heavy red dotted line shows the metropolitan Charles River sewer. The semicircles are sort of conventional signs, to show the location of the sewer overflows. Those sewer overflows are shown all along the Charles River, but have not been indicated within the Muddy River and Stony Brook areas. This blue line running through the middle of the Stony Brook area, the solid blue line, shows the portion of Stony Brook conduit which has been already built and covered in. That is, it is covered, — a continuous brick conduit. Above this point, Green Street, those blue lines show the open channel of the brook and its main tributaries. In the same way the Muddy River is indicated by a blue tint. In the lower part of Roxbury the remnant of the old channel of Stony Brook is indicated by a green line, extending from the Fens up there to Roxbury Crossing. From the junction of this line with the Fenway is shown a yellow line, which indicates the location of a 7 foot circular wooden overflow channel, which is designed to carry the foul flow of this rem-

nant of the brook to Charles River. It is also substantially the location of a proposed extension or by-pass channel for the main channel of Stony Brook, which has been projected but not yet built. At the lower end of the Muddy River water-shed is shown by a yellow line the 10 by 10 foot wood and concrete covered channel of the Muddy River, which serves the same purpose for Muddy River that the 7 foot channel does for Stony Brook, — to convey the flow directly to the river instead of through the Fens Pond, whenever it is considered too foul to go through the Fens or too dirty to go through there.

Q. (by Mr. DABNEY). What's that? Too foul? I didn't understand that. A. I said too foul or too dirty, or for some reason it was considered undesirable to let it go through those ornamental ponds. I think I have described all the lines shown on this plan and explained what the colors are for.

Q. (by the CHAIRMAN). The area there which is shown in white and which is within the Charles River basin has no sewerage system, as I understand. A. That's right; yes, sir.

Q. That is a less thickly settled portion, I take it, of the valley? A. Yes, sir.

Q. And the sewage is disposed of at isolated houses there, as in the ordinary way at country places. A. Yes, sir.

Q. (by Commissioner DANA). Have you any report that shows the sewage overflows for storm water into Stony Brook and Muddy River? A. I do not recollect any published report showing that.

Q. Could you make one, either on a separate plan or by adding to that plan? A. Indicating overflows into Stony Brook and Muddy River?

Q. Yes, any point where sewage gets in in storms or at any other times. A. Yes, sir; there are such points.

Q. There are some storm overflows, aren't there? A. Yes, sir; there are some storm overflows on Stony Brook; I don't think there are on Muddy River from Boston side.

Q. Do you know how far those are to be taken by the high-level system? A. How far the overflows are to be taken care of?

Q. Well, perhaps I didn't put my question quite clearly. How far at those points there is to be connection with the high-level system? A. Well, no, sir; I cannot say. The high-level system is not designed with reference to this; of course it is designed to take all territory above a certain level.

Q. Would they have a report showing where the pump is to be situated in the high-level system? A. That is to be located near the Charles River valley sewer, and practically take the whole of that out of the Charles River main sewer system.

Q. (by Mr. PILLSBURY). What are the points? A. It is not indicated here. I think it is very close to the corner of Vancouver Street and Huntington Avenue and Ward Street, as about as shown by the end of the red line there. I won't be absolutely certain as to that.

Q. (by Mr. DUNBAR). Here is another map, where it indicates the position; by comparing the two, you might locate it. A. That is practically the same point.

Q. (by Commissioner DANA). Have you ever made any estimate of how much sewage goes into Stony Brook? A. No, sir.

Q. Do you know how many outlets there are that overflow in case of storm? A. I cannot name the number now, off-hand, but there are quite a number.

Q. Perhaps you will prepare us a plan, or give us a statement later? A. Yes, if the commission desires it.

Q. Have you any idea of how much of the time these conduits are used and how much of the time the water flows naturally through the Fens? A. Do I understand you to refer to the two which I have described in yellow?

Q. Yes. A. The authorities of the Boston Park Commission would be better for that; but my idea is that this one for Stony Brook is used practically during all the dry weather, and no water from the old channel comes into the Fens except in pretty severe storms. The other, the Muddy River conduit, is used in a different way; and I think that that had better be described by some one from the park department, because I think they use it part of the time for renewing the supply or for effecting circulation in the Fens, but the details of that I am not familiar with.

Q. (by the CHAIRMAN). Can you indicate what progress is likely to be made in Boston, or if there are plans under way for introducing the separate system? A. No, sir; I cannot; that is too much for me to forecast. I can only say that it is the intention ultimately to develop the separate system throughout the city, and that will probably take place in the outlying districts first, and in the city proper, the business sections of the city, last, and possibly never there, but it will pretty certainly in the large outlying areas. That, of course, is involved in the pumping system. It is necessary that the combined system should be changed

into a separate system, and it is being done wherever it is feasible to do it. The department has it constantly in mind, and effects it whenever it can conveniently.

Q. (by Commissioner DANA). Are there any plans on foot for the betterment of the conditions in the Fenway at present? A. There has been a plan worked up by the sewer office and the city park department, also by the advice of Mr. Jackson, the city engineer, to build a by-pass or foul flow channel for the purpose of turning the flow of Stony Brook when it is muddy or otherwise objectionable directly into the Charles River without going through the ponds of the Fenway, but there has been no construction.

Q. You say when it is objectionable, — is that objectionable just for being muddy, or objectionable because there is sewage in it? A. Well, usually both conditions occur at the same time.

Q. Boston is well provided, is it not, with catch-basins for the street drainage, and so forth? A. Yes, sir.

Q. And those are kept well cleaned? A. As a general thing; it is intended to keep them well cleaned.

Q. (by Mr. MATTHEWS). That map does not pretend to be accurate, does it, with respect to the areas of the separate system? A. Well, fairly accurate.

Q. I don't see any large area devoted to the separate system of Cambridge shown on this, — Mr. Hastings' plan; I do not see that noticed on your plan. A. Well, we have made that up from our information as we understood it, and those are from the reports of the Metropolitan Sewerage Commissioners. There was no consultation with Mr. Hastings' office.

Q. You have not indicated the separate system of Cambridge on there? That's right, isn't it? A. I guess that's right; yes, sir.

Q. To that extent it is inaccurate, isn't it? A. Yes, sir.

Q. Now, isn't it true that the city of Boston is already putting in the separate system to a greater extent than is shown on your map? A. No, sir; I think we have shown —

Q. Practically all the sewer system that is being built is on the separate plan, isn't it? A. No, sir; it is not.

Q. Where are they building sewers now in the suburban part of Boston on the combined system? A. Well, I cannot say. I do not recollect of any being built on the strictly separate system. We have a proposition which we are so certain will be carried out that we have indicated on that

plan at that point there a separate system, — that is the Talbot Avenue system.

Q. That is over in Dorchester? A. Yes, that is over in Dorchester.

Q. (by Commissioner DANA). Does that have anything to do with the Charles River? Does that come within the Charles River area? A. The Talbot Avenue system? Yes, sir; it lies in the water-shed of Stony Brook.

Q. (by Mr. MATTHEWS). From that area a good deal of mingled sewage runs into Stony Brook, now, doesn't it? A. Yes, sir.

Q. And that has to be taken out, hasn't it? A. That will be; yes, sir.

Q. And you say that in the end you expect to introduce the separate system all over the city as fast as you get the money? A. Yes, sir; that is the intention.

Q. Have you anything at the office showing the area of land which contributes to the storm overflows of Charles River or Stony Brook? A. No; we have no other than this. This represents the area. We have no other map for that purpose.

Q. And haven't you any record as to those storm outlets or the length of time or volume? A. No, sir.

Q. You said that the waters of Stony Brook are not now discharged into the Fens except during storm flow. Are you right in that statement? A. I beg pardon. I think I was very particular to state the waters from the old channel are not discharged into the Fens except during storm flow.

Q. As a matter of fact, doesn't the whole of Stony Brook discharge now into the Fens through the new conduit? A. The whole of Stony Brook discharges into the Fens through the new conduit.

Q. The entire water-shed above the Boston Belting Company discharges now into the head of the Fens? A. Yes, sir.

Q. There is no way for that to get out to the river except through the Fens? A. Yes, sir; that's right.

Q. And that has been so for about three or four years? A. That has been so since some time in 1897, I think.

Q. 1897 or 1898? A. Yes, sir.

Q. There are plans in the office, are there, for the complete drainage into the conduit of the sewers of the houses on the water side of Beacon Street? A. Yes, sir.

Q. And also for the complete drainage which now opens into Stony Brook water-shed? A. Yes, sir.

Q. (by the CHAIRMAN). There is yet considerable house

sewage goes into Stony Brook water-shed, is there? A. On this old channel there is considerable that goes or finds its way there. We know that to be the fact. There is none understood officially to be going through there, but we know very well that it is so, and the houses on the water side of Beacon Street will all drain in there.

Q. Those are the only ones of house sewage? A. Except isolated instances along the brook valley where the system is not completed, but those are not many.

Q. (by Commissioner DANA). With the amount of sewage that flows into the Fens, have there been any offensive conditions? A. Yes, sir; there have been complaints made by the park authorities, and an attempt has been made to devise remedies.

Q. (by Mr. MATTHEWS). Won't you state to the committee what that attempt was, if you remember? A. The problem was to provide a channel from the point where Stony Brook, the new commissioner's channel, discharges into the Fens to Charles River, for the purpose of turning the flow directly into the river whenever it is necessary to do so, without going through the Fens, whenever it was offensive or objectionable to the Park Commissioners; and the question was, how much should be so turned. It might of course be considered necessary to turn the whole of it, because the water is more or less muddy, even during the greatest freshet. That would involve a channel of the same size or even greater, because the same size as the Stony Brook channel would not carry as much, owing to the decreased grade; but after careful consideration in our office we came to the conclusion that, if a channel was provided which would take off about 80 per cent. of the storms, it would be as well as it would be possible to do practically, because the water in the extreme freshet is not of course very objectionable.

Q. (by Mr. MATTHEWS). Is not what? A. Is not objectionable, because, although it may be turbid to the sight, there is but a very small percentage of objectionable material in it; therefore it is not necessary to provide for the extreme flow.

Q. (by Commissioner DANA). Has your office ever considered what proportion of sewage it is safe to have in proportion to the amount of fresh water coming in? Have you got any formulæ for that? A. No, sir, we have no formulæ; and I do not quite understand the question. Safe for what purpose? To be discharged into the river, or into the Fens?

Q. I didn't know but that you had some formula for the number of cubic feet of pure water per second that must come in for every 1,000 of population draining into a river, in order to prevent unwholesome odors. A. No, sir; we have not gone into that question. But the result of this study, to complete the statement, was that our office designed a 12 by 12 channel to be built on very nearly the line of the existing channel, of course at a large cost. This scheme was subsequently modified by the suggestion of the city engineer that for the present this might be built between the new channel and the old, and be connected temporarily with the old channel, and might serve for a number of years, and serve to carry the flow; and in that way the project rested. The money has never been provided.

Q. (by Mr. Pillsbury). A closed conduit 12 by 12? A. Yes, sir; a closed conduit 12 by 12.

Q. Where was that to enter the river? A. Practically at Charlesgate east, where the Fens ponds enter and where the 7 foot conduit of Stony Brook enters.

Q. (by Mr. Matthews). That conduit which you designed would carry how much of the sewage to Charles River? A. A varying amount. I think the amount varied from 300 to 700 cubic feet, according to the height of tide in the river.

Q. What percentage of the flow of Stony Brook, was my question. A. Well, that would also depend on the flow of Stony Brook at the time. I cannot say the percentage, but that would not be a constant percentage. For small storms it might take care of the whole of the flow.

Q. I understood you to say that that did not take care of the whole of the overflow, but only storm water. A. No, sir; it does not; it is not for the whole of it.

Q. How much of the percentage of the flow of Stony Brook, was my question. A. If it was flowing its maximum capacity of 2,000 feet, the difference between 300 and 700 and 2,000 feet would have to go through the Fens; but, in my opinion, the overflow channel would be of no particular use in one way or the other during those times; there would be no necessity for using it.

Q. The water would be so diluted? A. Yes, sir; the water would be so diluted.

Q. The chairman asked if there was any house sewage going into Stony Brook yet. A. There is some pollution, we cannot deny, along here.

Q. What plans are under consideration for that? A.

The plans are in our office, and have been under consideration for years for this contemplated channel, this old channel in Rogers Avenue and Ruggles Street, to rebuild it with brick and build house sewers on each side and cut it off from everything. We have plans already to do that.

Q. (by Commissioner DANA). House sewers would be separate in that case? A. Entirely separate; yes, sir; on the intercepting system.

Q. (by Mr. DUNBAR). How long have you had those plans in your office? A. I cannot say; several years.

Q. Five or six years? A. I think so.

Q. More? A. No, hardly; not in a complete state.

Q. You have given us a pretty good description of Stony Brook. I want to ask a question about Muddy River. Is there any sewage that goes directly into Muddy River?

Q. (by Mr. MATTHEWS). You have given the chairman an account of one scheme to improve Stony Brook. Now, wasn't some excavation made two or three years ago at the outlet of Stony Brook and the Fens, — are you familiar with that experiment? A. Yes, sir.

Q. Or that operation? If so, I wish you would explain it. A. Yes, sir; it was alleged by the Park Commissioners that Stony Brook caused a deposit in the Fens, and this deposit was finally cleared out by dredging.

Q. Do you know exactly how that was done, — do you know the details of the operation? A. In a general way. It was pumped up, carried by hydraulic dredge, emptied into the 7 by 7 conduit, sent down to the river and caught in a basin which had been previously dredged for that purpose; then it was dredged up from that basin and floated away.

Q. Then, as I understand this operation, an accumulation of mud or other objectionable material had formed at the head of the Fens and Stony Brook? A. Yes, sir.

Q. And that was taken by hydraulic suction to this Stony Brook conduit and allowed to flow out into the river by Charles River? A. Yes, sir.

Q. And there it settled and formed a deposit there which was removed by dredging? A. Yes, sir; that was done.

Q. Let me ask you one further question about Stony Brook. Was there any trouble with Stony Brook making any deposit in the Fens prior to 1897 or 1898, before which date only the storm flows were allowed to go into the Fens, if I understand it correctly? A. I don't remember of any complaint having been received before that time.

Q. And it is true, is it not, that the ordinary dry

weather flow of Stony Brook went down the old channel and through this conduit to the river, and only the storm flow went into the Fens; that is right, isn't it? A. Yes, sir; when the flow was not too great for this, it was sent down the old channel.

Q. But when you extended Stony Brook above, you lowered the bed of the stream so that you could not do that, and you had to turn it all through the Fens into the river; that is right, isn't it? A. That is right; yes, sir.

Q. And it has since then passed down through the Fens into the river? A. Yes, sir.

Q. (by Mr. DUNBAR). You say that was dredged out, — when, Mr. Dorr? A. I cannot recollect the year with certainty; 1897 or 1898, I think.

Q. About three years ago last summer? A. Yes, sir; about three years ago last summer.

Q. That is all filled up again, isn't it? A. I have not been informed that it was, or heard any complaint from the Park Commissioners to that effect, so I do not know.

Q. Is there any more than 6 inches there now? A. I am sure I do not know.

Q. You spoke of the water which came in there having produced objectionable features. What would be the effect, if things are left as they are now, of having the water maintained at a permanent level, or at grade 8? Would the objectionable features be increased? A. Do you refer to maintaining the water at grade 8 in the basin, in the pond, or in Charles River?

Q. If in the Charles River basin, it would be in the Fens also, wouldn't it? A. Yes, sir; it is now maintained practically at grade 8 in the Fens.

Q. Isn't there free communication between the Fens and Charles River basin, so that the water runs in freely at the rising of the tide? A. That is something that can be obtained from the park engineer. There is a flow maintained, but how much I do not know.

Q. Is there any direct sewage into Muddy River? A. Not from Boston side. There are no overflows from the combined system on the Boston side. I won't say about overflows from the combined system on the Brookline side.

Q. Could you tell how many there are, and where they are? A. No, sir.

Q. What would be the effect upon the water in the Fenway if the water should be kept at grade 8 in the basin? A. Well, I should suppose it would aid them in keeping the Fens ponds at grade 8.

Q. Is there any difficulty about that? A. I don't know that there is.

Q. Would it have any other effect? A. I don't think of any other effect, but I am not very familiar with the management of the ponds in the Fenway.

Q. Who is familiar with that? A. The engineers of the Boston park department.

Q. (by the CHAIRMAN). Have there been any computations made, or are there any data in your office, by which you can tell us approximately how much it would cost to make the changes you have in your office contemplated, — to make the changes from the combined system to the separate system throughout the city? A. No, sir.

Q. Are there any with reference to this district of the Charles River basin on this side of the Charles River, — I mean the south side? A. That is, of practically converting the brown area to blue area?

Q. Yes. A. No, sir; I don't know of any.

Q. Have you yourself any idea how much it would cost? A. No, sir; I should not want to name any figures; I should want a great deal of time to make a study of that.

Q. You could not give us any approximation? A. No, sir; I should not be willing to.

Q. Would it cost two or three millions? A. I should think it might.

Q. (by Mr. MATTHEWS). Whatever the cost, I understood you to say that that ought to be done, and probably would be done, in time? A. Yes, sir.

Q. Irrespective of this question of the Charles River dam or basin? A. Yes, sir; entirely so; on account of the pumping system.

Q. (by Mr. DUNBAR). Have you any idea in what length of time this could be done? A. No, sir.

Mr. George Howland Cox, chairman of the park commission of the city of Cambridge, submitted the following report: —

CAMBRIDGE PARK COMMISSION, CAMBRIDGE, Jan. 16, 1902.

Committee on Charles River Dam, 14 Beacon Street, Boston, Mass.

GENTLEMEN: — The city of Cambridge has acquired the entire northern shore of Charles River, from Craigie bridge to Gerry's landing, excepting about 1,360 feet below Cambridge bridge, 175 feet of which has been taken by the Cambridge bridge commission. The length of shore in actual possession of the city is about 22,540 feet, or a little over 4¼ miles. This taking varies in width from 655 feet to 76 feet, and contains 5,314,683 square feet, or 122 acres. Of this frontage of 22,540 feet, 8,360 feet are bordered with a sea wall and 2,500 feet

more of wall will be completed in the future. The remainder of the Cambridge park taking is or will be treated with a beach construction, of which 5,240 feet have been constructed, leaving 6,440 feet to be completed.

The surface area in parkway between West Boston bridge and Cambridge hospital to be filled and brought up to grade is about 25 acres.

It is the purpose of the commissioners to build a boulevard and parkway the entire length of the Cambridge shore, that portion between Harvard bridge or a possible new bridge at St. Mary's Street to be the connecting link in the metropolitan driveway connecting the great metropolitan reservations in the Fells with those in the Blue Hills.

Very respectfully, GEO. HOWLAND COX.

Q. (by Commissioner DANA). The parts of the bank of the river that have been now graded and beached and finished are done with reference to the tidal system in the river as it now exists? A. Entirely so; yes, sir.

Q. Would there be any saving in the construction of the balance if a constant level of somewhere near grade 8 was maintained? A. There would be a large saving; yes.

Q. Have you any way of estimating what the total saving of expense would be? A. I have figured it rather roughly, from such data as I could get. I figured the total cost of the construction of the beach without the dam at $112,700; with a dam I figured the cost at about $50,000, making a saving of $62,000 in the length of beach which we have to build. Of course the saving comes in not having to dredge or fill, as the case may be, at the foot of the beach. In many cases along the river the shore is very muddy, and we have been forced to take a dredge up there to remove the mud, and it is very expensive. We would not be obliged to put the gravel so far down the slope as we do now, with water at a permanent level.

Q. Would you fill to the same grade back of the beaches with the constant level maintained there? A. We should not fill at all.

Q. And is that included in this estimate of $62,000? A. No; I did not put that in there. I included the cost of bringing the territory up to grade for the city alone at about $100,000.

Q. Well, then, there would be $100,000 saved besides the $62,000, — do I understand that right? A. Yes, sir; so I estimate it, and then there would be an additional saving on about 2,500 feet of sea wall, which would not need to be so substantial if we did not have to go to extreme low water. I figured that at about half, or $50,000, but there is a good deal of guess about it.

Q. (by Mr. DUNBAR). This saving is based upon the

assumption that the water in the basin is to be kept at constant level, isn't it? A. Yes, sir.

Q. If the plan should be to let the water out occasionally, you would make none of the saving you have estimated? A. No, sir.

Q. (by Commissioner DANA). Would the letting out affect it? A. No; the coming in would.

Q. (by Mr. MATTHEWS). If the basin were opened only once in a while? A. The foot of the beach would be in a very ragged condition; of course it would be a very nasty and disagreeable mess.

Q. It would be mud, just as it is now, wouldn't it? A. Yes, sir.

Q. It would not be any worse than it is now? A. No, I don't think it would be; I think it would not hardly be possible. It might be done in the night.

Q. Let me ask you in regard to maintaining a constant level of fresh water, with regard to the planting along the river. A. We have had no experience in regard to that, but our landscape architects have studied that, and we have about got to their views. If we could plant deep-rooted trees, oaks and such as that, we should rather do so than plant the stunted shrubs such as we now have to use.

Q. Is your planting now almost entirely restricted to stunted trees and shrubs? A. Almost entirely so.

Q. You could not plant oaks or any other deep-rooted trees? A. No; we have nothing planted.

Q. No trees? A. Nothing only where we have brought the shore up to the grade where we can do it with safety.

Q. What is the height of your planting area now, above high-water mark, where you are making an artificial shore? A. I am not positive, but I should say 4 or 5 feet.

Q. (by Mr. DUNBAR). Does your plan of development contemplate raising to the planting grade throughout? A. Yes, sir.

Q. It does? A. Yes, sir.

Q. (by Mr. MATTHEWS). If you had fresh water in the basin there you could plant deep-rooted trees, but not with salt water? A. Certainly. We have been carrying that on, regardless of the question of dam or no dam; we have had to lay out our plans under present conditions.

Q. You have had to lay out your plans under the present condition, on the assumption of having a basin filled with salt water? A. Entirely so.

Q. (by Mr. DUNBAR). What distance would you have to go back from the water to plant if fresh water was in the

basin? A. I could not answer that; we would have to go back far enough so that the salt water would not affect the shore. The data are easily obtainable.

Q. Would your park commission know about that? A. I think we could obtain it.

Q. I should be glad to know that, if it could be got. A I will see if it can be done.

Dr. HENRY J. BARNES. As the representative of Tufts College Medical and Dental Schools, I desire to say they would desire to be heard on this subject, where their interests appear to be at hazard in the matter.

The CHAIRMAN. Would you kindly send a statement of that kind to the committee?

Dr. BARNES. Yes.

The following statement was filed with the committee by Dr. Barnes: —

BOSTON, Jan. 30, 1902.

To the Honorable Commissioners investigating Plans for improving the Charles River.

GENTLEMEN: —We, the undersigned, representing the faculty of Tufts College Medical and Dental Schools, respectfully call your attention to the sewage discharged into the Fens basin near the location of the two schools, and the dangers we apprehend of unsanitary results if the present practice of flushing the basin with tidewater is discontinued, without other provision for maintaining the purity of the water of the Fens basin than appears in the joint report of 1894.

ELMER H. CAPEN,
HAROLD WILLIAMS, M.D.,
HENRY J. BARNES, M.D.,
Committee.

Mr. FREDERIC D. FISK. Mr. Chairman, in behalf of the trustees of the Main Street Land Trust, I desire to say that we have prepared a statement in writing, setting forth what we believe would be the effect of a dam upon the interests entrusted to our care, and our statement we desire to file with your committee. We do not wish to appear here as being in opposition to the dam; we do not wish to be so understood. We believe that our interests are entirely such as can be adequately provided for by compensation for damage suffered.

The following statement was read: —

The trustees of the Main Street Land Trust hold title to a tract of so-called flats in Charles River, adjacent to the Cambridge shore, and extending from the southerly side of the temporary bridge as now standing to the easterly line of the property of Edward Kendall & Sons, pro-

duced southerly toward the channel of the river. The title to this tract was questioned by the Commonwealth of Massachusetts, acting by its Board of Harbor and Land Commissioners; but the title of those persons who are now the beneficiaries under the trust was confirmed by a decree of the superior court for the county of Suffolk, dated April 10, 1896.

The area of this tract is over 1,500,000 square feet, and it consists of a bed of fine, pure gravel or sand. No occasion has yet arisen requiring the trustees to accurately ascertain the depth of the gravel or sand, but such tests as have been made show that, except for occasional and infrequent knobs of clay, the depth of gravel or sand is more than 20 feet.

About one-quarter of the superficial area of the tract has been partially dredged, or, to state the present situation with as much accuracy as possible, about 400,000 square feet have been dredged to an average depth of between 10 and 11 feet. Thus the gravel which has been already sold and removed can be fairly estimated to have been about one-eighth of the total contents of the bank, and, as the sum of $27,500 has been realized from the sales, it can be easily seen that the remaining seven-eighths represent about $200,000, assuming that no more can be realized per cubic yard than the average price in the past. This, however, is not the fact. The most recent sales have been made at a price per cubic yard 33⅓ per cent. more than the average price of all gravel sold; and the trustees believe that they can realize a still larger return per cubic yard by having the gravel or sand dredged and landed on a wharf or wharves conveniently located for the consumers, and selling it from the yards rather than selling it in the bank, as they have been obliged to do up to the present time. The expenses attendant upon the filling of the large tract of land enclosed by the sea wall have prevented the trustees from developing the gravel bank; but as those expenses have now ceased, the trustees hope and expect to begin this spring on the gravel.

The building of a dam at any point below the gravel bank will affect its value in three ways: first, maintaining the water at a fixed level or preventing the level of the water from dropping as low as it falls at low tide at the present time will make it necessary to dredge in deeper water; second, a dam, if constructed without a lock, would prevent the landing of the gravel or sand at any points except such as might be available on the river above the dam, and would completely cut off deliveries at any points below the dam; third, a dam, if constructed with a lock, would so delay transportation as to materially increase the cost of such transportation, and would further necessitate a larger fleet of scows or other transporting vehicles to compensate for the delays.

The extent of the damage caused by maintaining the water at a fixed level would depend upon the level at which the water might be maintained. By suiting the location of the dredge to the rise and fall of the tide, it is never necessary to work in over 20 feet of water under the present conditions, unless it is desired to dredge to a greater depth than 20 feet below low water; but if a dam is built, the extreme depth of water in which the dredging must be done will be as much more than 20 feet as the established level of the water in the basin is above the present low-tide level. The trustees are unable to give any information as to how much the increased depth of water would increase the cost of dredging, as it is a condition which they have never had occasion to meet.

The extent of the damage resulting from the building of a dam without a lock would depend in some degree on the location of the dam,

although the building of a dam at all would be a great damage. A dam at Cambridge bridge would be equivalent to a confiscation of the gravel bank, because above that point on the river there is no wharf on the Cambridge side, and there soon would be none on the Boston side; in fact, there is now no wharf on the Boston side available for this purpose. In order to obtain a satisfactory price for their work from the dredging companies, it is necessary to move the gravel in quantities of not less than 5,000 cubic yards, and this quantity of gravel means on the wharf a pile 225 feet long and 20 feet high. The cutting off of all opportunity to market any part of the 5,000 cubic yards at any point or points below the dam would make it necessary to receive the whole amount on the wharf, and the expense of such wharfage in the rear of Charles or Brimmer streets would be prohibitive. A dam at Craigie bridge would give an opportunity to use the wharves on the Cambridge side of the river between Cambridge and Craigie bridges, but would still cut off the markets below the dam. As has been said, the trustees believe that the largest return can be realized by landing the gravel or sand upon wharves conveniently located for the consumers; and to be restricted to wharves above Craigie bridge on the Cambridge side of the river would seriously restrict the area of delivery in which we could successfully compete. In 1893, 1894 and 1895 all the beach gravel used by the city of Boston was dredged from this bank and delivered to the different city yards, including South Boston and East Boston as well as the city proper. Jealousy between the contractors resulted in cutting the price so low that they were refused the privilege of taking gravel from this bank, and only recently has the price been restored. Each spring, including last year, contractors have asked to be allowed to bid on gravel to be furnished from this bank, and this spring the trustees intend to allow such a bid or bids to be made.

The extent of the damage resulting from the building of a dam with a lock would depend upon how great a hindrance to transportation the lock might prove to be, and upon how much it increased the cost of transportation. It is to be remembered that this gravel wherever it may be offered for sale must compete with like material brought to the city by water or rail, and every increase in the cost of handling is a positive and absolute reduction in its value. One serious delay from the lock would be the necessity of at least two openings for the passage of each group of scows. A tow-boat can easily manage four, five or even six scows, and the expense of towing is practically the whole of the expense of transportation. Unless the lock is large enough to pass a tow-boat and four or five scows at one opening, either the tow boat must make at least two trips through the lock with each group of scows, or additional tow-boats must be employed.

In the foregoing statement no mention has been made of the difficulties in regard to the dredge itself, but discussion has been confined to the effects of a dam on the value of the gravel bank. A few words should be said in regard to the dredge.

The building of a dam without a lock would necessitate either floating a dredge into position before the dam is closed in, or building and equipping a dredge above the dam after it is finished, and in either case taking the whole machine to pieces when the bank is exhausted. Either would be very expensive. The building of a dam with a lock, if the dam and lock were located at or below Cambridge bridge, would not relieve the situation in regard to the dredge, because it would probably be impossible for the dredge (with its high "A" frame, so called) to pass under the bridge. The clear head room under the bridge is to be 26 feet at mean high water, or about 37 feet at extreme low water;

and, if a dam is built, from this 37 feet must be deducted the difference between extreme low water and the permanent level of the basin.

In this statement reference to the amount of damage under the different conditions has been avoided as far as possible, because it is believed that your honorable committee would not wish to hear argument on that question; and all reference to possible damage to the filled land owned by the trust has been omitted, because all that is material on that point will doubtless be presented to your honorable committee by the able counsel representing the owners of similarly located land on the Boston side of the river.

Q. (by Commissioner DANA). What is the size of the scows you use? A. They vary in size, — from scows which hold from 40 to 70 cubic yards. I think 70 to 75 are the largest they use in Charles River.

Q. Do you know the length and width of those scows? A. I do not. They vary with every operation. There are two or three different sizes. With every fleet there may be one 40 and one 70 and perhaps one 60 yard scow.

Q. Do you know the height of the dredge? A. The average height of the "A" frame, on what is known as the dipper dredge, is 50 feet above the deck, and on a clam-shell dredge about 30 feet above the deck.

Q. (by Mr. MATTHEWS). Those dredges cannot get up the river after the West Boston bridge is built, can they? A. Almost any dredge of what is called the clam-shell kind can go up. Such a dredge would be about 34 or 35 feet above the water, and there will be 37 feet of head room under the bridge at extreme low tide.

Q. Well, then, why couldn't your scows go above this dam? A. The permanent level, I suppose, will be somewhat above the present low-tide level, and whatever is the difference between these levels, must be deducted from the 37 feet.

Q. You say as it is the height above the water would be how much? A. Thirty-five feet.

Q. That would be too much to go through the Cambridge bridge as it will be when built? A. The extreme height of the bridge, as fixed by the statute, is 26 feet above mean high water, or 37 feet above the water at extreme low tide.

Q. If you waited for extreme low tide you could get through, couldn't you? A. Yes, that would be cheaper than to build a dredge above the bridge.

Q. With 28 feet of head room, could all of the dredge, except the "A" frame, pass under the bridge? A. Undoubtedly there is no part of the dredge except the "A" frame that would not go through readily, and I suppose that could be taken off readily.

Q. How many scows go up or down at a time hitched together? A. I think six is the most I have seen. Our business below the bridge has almost entirely been done on self-propelling lighters. There would be no difficulty for them to go through the lock, but it is inconceivable that business will continue to be done that way. The gravel to be put on the wharf must be carried through the lock in scows.

Q. How many would be permitted to get by the railroad company's draws, — to go through their draws? A. I could not say. I have seen a tow-boat come up through the bridges with at least ten empties when they were coming up to do work on the river. They were empty, however. Whether that would make any difference to the railroad or not I do not know.

Q. Couldn't your scows be accommodated in a lock 50 feet wide and 400 feet long? A. I think they could.

Q. Will you point out where your bank is situated? A. Immediately south of what is marked West Boston bridge here, extending out into the channel of the river. It is practically below mean low-water level, none of it above.

Q. All are on the tidal flats, ebb and flow? A. Yes, sir.

Q. (by Mr. Abbott). Hasn't most of the dredging on your gravel bank been done by hydraulic dredgers? A. So far as I know, there has never been a hydraulic dredge on it.

Q. Haven't you used material from that in filling your own land? A. No. We especially prohibited them from using a hydraulic dredge on it. The gravel bank seems to be like a hill in the river.

Q. Where did you ever use them? A. Absolutely outside of the gravel bank.

Q. To whom have the sales of your gravel been chiefly made? A. They have been made to the city of Boston, the New England Dredging Company, a large quantity was used for the filling of the streets on what is known as the Embankment Company land on the Cambridge side, and then a considerable amount to the Cambridge Park Commission, and, of course, to private parties. Those have been the largest sales.

Q. Have you any idea of the relative amount sold for use in Cambridge and for use elsewhere? A. No, not except that I might guess at it. It would only be a guess, and I should rather not make it; perhaps it would not amount to anything.

Mr. E. B. Bishop. I appear for the Cousens estate, which owns Cousens wharf.

Q. (by the Chairman). Will you indicate on the map where that is located, please? Just where? A. It is nearly at the crossing of the Brookline Street bridge, sometimes called the Essex Street bridge.

Q. You have filed a statement with the commission? A. No, not yet.

Q. You will do so? A. Yes, sir.

Committee adjourned, to be convened again at the call of the chairman.

FIFTH HEARING.

ROOM 203, CONGREGATIONAL HOUSE, BOSTON, Jan. 29, 1902.

The fifth hearing before the committee on Charles River dam was held to-day at 10 A.M., at Room 203, Congregational House.

Present: Chairman Henry S. Pritchett and Commissioner R. H. Dana.

Mr. X. H. Goodnough, engineer of the State Board of Health, presented the following report: —

OFFICE OF STATE BOARD OF HEALTH, BOSTON, Jan. 23, 1902.

To HENRY S. PRITCHETT, *Chairman of the Committee on Charles River Dam.*

SIR: — The public work of the State Board of Health, so far as it relates to the proposed dam in Charles River, is the work required in relation to the general oversight and care of inland waters, under the provisions of the Public Statutes; and the work upon the examination of sewer outlets and the effect of sewage disposal, under the provisions of chapter 104 of the Acts of 1901.

The proposed dam, it is assumed, would be located a short distance above Craigie's bridge, between Boston and Cambridge, and would raise the water to a constant level about 8 feet above the Boston city base. The information collected refers to the quantity of sewage discharged into the river and its tributaries above the dam, and the relation of this quantity to the flow of the stream after the dam shall be built, and the effect of such discharge upon the sanitary condition of the river.

The Charles River, above the proposed dam, drains an area of about 306 square miles. Near Dedham there is a channel leading from Charles River into the Neponset River, which is known as Mother Brook; and it has been decided by the courts that Mother Brook is entitled to one-third of the water of the Charles River at the point of diversion. Taking out one-third of the drainage area above Mother Brook, the total water-shed of the river at the proposed dam is approximately 239 square miles.

The upper portion of the Charles River water-shed is for the most part sparsely populated. At Milford, near the extreme upper end of the water-shed, there are two sewer outlets discharging into the river the sewage from about 600 people. At Milford, Franklin and Medway manufacturing wastes are discharged into the stream from factories and mills at several places; but so far as known there are no other sewer outlets into this stream between those at Milford and the proposed basin, a distance of about 56 miles along the river, and the river above the latter point is more free from direct sewage pollution than any other of equal size in the eastern part of the State.

The sewage from Cambridge, on the northerly side of the proposed basin, is collected into a branch of the north metropolitan sewerage system, which discharges at Deer Island. The sewage from Waltham and Watertown, on the northerly side of the river above Cambridge, and the sewage of Newton, Brighton, Brookline and the Back Bay district of Boston, together with sewage from the westerly side of the city proper bordering on the Charles River and from the valley of Stony Brook, one of its tributaries, finds an outlet through the main drainage system of the city of Boston at Moon Island.

The sewers of Waltham, Watertown and Newton are constructed upon the separate plan, storm water being kept separate from the sewage. In Brighton, Brookline and Boston the sewers are constructed largely on the combined plan, and receive both sewage and rain water. When the main drainage and metropolitan sewers were built, and intercepted the local sewers, valves were placed at the connections with the intercepting sewers whereby the flow of local sewers at times of storm is largely shut off from the intercepting sewers and discharges through the former outlets, and in the district bordering Charles River these outlets discharge into the river or its tributaries. Since the Boston main drainage system was constructed a much larger area has been connected with it than was originally planned, and the quantity of rainfall that can be received from the districts having combined sewers as a whole is much smaller at present than provided for in the original plan.

On the north side of the river in Cambridge their sewers were constructed upon the combined plan originally, and sewage and storm water were received into the sewers. At the connections with the local sewers valves are placed similar to those on the Boston side of the river, by which the excess of flow at times of storms is discharged through original outlets into Charles River.

Sewers on the separate system are now being built in Cambridge, which are connected directly with the metropolitan sewer without shut-off valves; and in connection with the separation of the sewage from storm water, sewers have been built for storm water only, which discharge directly into the river. The capacity of the Cambridge branch of the metropolitan sewer for receiving storm water is much greater than the capacity of the metropolitan and Boston main drainage sewers south of the river, and the quantity of mingled sewage and storm water discharged into the river is less in Cambridge in proportion to the area than in Boston.

The total number of storm overflow outlets from the metropolitan sewers into the Charles River above the proposed dam is about 30. There are also about 25 overflows, so far as known, from sewers in the valley of Stony Brook, from which mingled sewage and storm water may be discharged into that stream at times of storms.

The calculated quantity of sewage discharged into the river and Stony Brook from these various overflows is equivalent, at the present time, in a dry season, at the time when the flow of the river would be lowest, to the sewage of about 4,300 people discharging continuously; but this sewage, as a matter of fact, does not discharge continuously, but at irregular intervals during rains at many outlets all along the shores of the basin and along Stony Brook, — a condition favorable for a thorough dilution. To this should be added the sewage of about 1,000 persons in houses along Beacon Street in the Back Bay district of Boston, which are said to have independent outlets into the river.

The Boston main drainage system receives at the present time the sewage from a very much larger area than that for which it was originally designed; and a new main intercepting sewer, known as the high-

level sewer, is now being constructed from the Back Bay district of Boston in a generally south-easterly direction across Boston and Quincy to an outlet near Nut Island. This sewer is designed to take the flow of sewage from the Charles River valley metropolitan sewer and areas in the Back Bay district of Boston, together with the sewage of portions of Dorchester, Roxbury and West Roxbury, which now flows into the Boston main drainage system, and to convey it, with other sewage, to the new outlet near Nut Island. This sewer, which is of very large size, will, when completed, receive all of the sewage of the Charles River valley metropolitan sewer, with additions from some of the Back Bay districts, and of a large portion of the Stony Brook valley, and it will provide for removing many times the quantity of storm water which can now be received into the Boston main drainage system; at the same time, by relieving the Boston main drainage system of the flow of the Charles River valley and other sewers, the completion of the high-level system will greatly increase the capacity of the Boston main drainage system for removing storm water.

After the high-level sewer is built, probably within two years, it is calculated that the quantity of sewage that will discharge through the storm overflows in a dry season, when its dilution by the flow of the river would be the least, would be equivalent to the sewage of about 2,400 people, and, adding the population in houses along Beacon Street, to 3,400 people, discharging sewage all the time; but this discharge, as already indicated, will take place during rains at irregular intervals and at numerous outlets all about the basin.

Comparing the quantity of sewage that would be furnished by 3,400 people with the estimated flow of the river for the three driest consecutive months that have occurred within the last twenty-seven years, the dilution by the flow of the river alone would be far greater than the amount which is regarded as essential for the prevention of objectionable conditions under such circumstances.

The condition indicated herein which will exist when the high-level sewer system is completed will doubtless be modified by future growth of population and changes in the systems of sewerage. If nothing further should be done to prevent sewage entering the river or its tributaries through storm overflows after the construction of the high-level sewer, it is unlikely that the increase in the quantity of sewage discharged into the basin through such overflows would produce objectionable conditions. A material enlargement of the areas served by combined systems of sewers is impossible under existing laws, and the work of separating the sewage from the storm water in areas already provided with sewers upon the combined plan has been undertaken within the district tributary to the basin; and a reduction in the quantity of sewage entering the basin and its tributaries through storm overflows will gradually come about if this policy is adhered to, — and the sanitary interests of the district require that it should be adhered to.

A considerable fraction of the present pollution of the river can be prevented by constructing an intercepting sewer, which shall take the sewage from Beacon Street houses, now discharging directly into the river, into the high-level system. This being done, the amount of sewage entering through the storm overflows at present or likely to enter at any future time would be so small, compared with the flow of water in the river, that it could not be regarded as a menace to the health of those boating upon the basin or living upon its borders,

By order of the State Board of Health.

SAMUEL W. ABBOTT,
Secretary.

Mr. Matthews requested Mr. Goodnough to supply the committee with the calculations which resulted in the opinion of the Board that after certain changes are made the amount of sewage entering this basin would be equivalent to that which would come from a population of 2,400.

Q. (by Mr. MATTHEWS). I understand that your calculation takes in possible pollution on both sides of the river? A. Takes in both sides of the river.

Q. And it includes all the area now drained by the Binney Street outlet? A. I think it does, but I am not sure about that; I think we included Binney Street, but nothing below that.

Q. That it should possibly stop at Craigie bridge? A. Yes.

Q. And upon the continuous draining of Binney Street in this basin? A. Yes.

Q. And whether or not this conclusion is not predicated on the present condition of Stony Brook, and what comes down from Dorchester and the Talbot Avenue district? A. The Talbot Avenue district was excluded.

Q. As it is now, or as it will be? A. As it will be, and as it is now.

Q. Have you simply taken out the amount of sewage that is now pumped by the city of Boston into Talbot Avenue, or the amounts by exclusion that will be removed after the city of Boston has completed its system? A. We have taken as it is to-day, in one case, and as it will exist after the system is completed.

Q. Then the 2,400 figure is predicated on the high-level system? A. When the metropolitan high-level system is built.

Q. That is not what I had in mind. I understand the city of Boston is making some changes, irrespective of the high-level system? A. In the Talbot Avenue district.

Q. I understood they were to have a main drainage system. If the city of Boston is making any changes in that district unconnected with the high-level system of the Metropolitan Board, then the changes that would be effected in that by the city have not been taken into consideration in your account? A. No, sir; they have not.

Q. You have taken into consideration conditions likely to come from changes in the high-level sewer, but not the changes, if any, likely to be made by the city of Boston? A. No; I will have to look up that further, Mr. Matthews.

Q. If you will, and send them at the same time you send your calculations? A. Yes.

Q. Does this calculation, resulting in the figure 2,400, is it predicated upon the elimination of the house drainage that now goes into Stony Brook? A. That figure 2,400 is based on reducing the quantity of sewage that now goes into Stony Brook, that will be the main tributary of the high-level system after the main sewer is built, and on the assumption that there will be some sewage from the Boston drainage after that is built.

Q. You are talking about storm overflow? A. Yes.

Q. I am talking about house sewage that now gets into Stony Brook. A. That is eliminated; it is assumed we should.

Q. This is also eliminated on the north side of Beacon Street, on the assumption that the city of Boston will also take care of that in some manner? A. That has been; yes.

Q. Have you, or anybody connected with your Board, made calculations as to the exact amount of relief which will accrue to the Boston main drainage system in the way of taking care of storm waters when your sewer is finished? A. Yes, that has been done.

Q. Have you those figures? A. I haven't them with me; I can make them up.

Q. I have made my question plain,—for some figures, data or calculations, showing the exact amount, volume, time or relief to the Boston main drainage system of the storm waters of the Boston Back Bay system which will accrue from the construction of the sewer of the metropolitan high-level system. Now, is there any storm overflow from the metropolitan sewers into the Charles River above the Watertown system? A. There are separate systems, as I understand it, which have overflows into the Charles River. These overflows are not intended for regular use, but for safety valves in case of emergency.

Q. Then you understand there is no overflow from common sewers into Charles River? A. As I understand, there is no overflow from the separate system of sewers.

Q. Is there not some overflow in cases of overflow from the sewers themselves, as distinct from the storm overflows? A. I think, on account of the surcharge of the Charles River valley, it is possible there are occasional overflows; I think, as nearly as I could get at that, perhaps twice a year an overflow might occur, perhaps as in the case of the Newton sewers.

Q. Any other overflows from any of the other towns above the Watertown dam? A. Not that I know of, as far as I have observed.

Q. Was there any injurious effect noticed from the overflows? A. Nothing that I know of.

Q. (by Mr. DUNBAR). Mr. Goodnough, would it be possible for you to give us also the volume of the flow of the river, — the calculated flow of the river? A. Yes. That I have calculated, on the basis of the driest three months we have ever had, at about 52 cubic feet a second at the site of the proposed dam at Craigie bridge.

Q. Does it receive any considerable accretions between St. Mary's Street and the proposed dam? A. It receives Stony Brook and what comes out from the Fens.

Q. What accretions does it receive there? A. They are extremely small.

Q. Does it make any difference, Mr. Goodnough, whether sewage is put into a stream which has free access to the ocean, or into a body of water where there is a dam? A. I don't think free access has anything to do with it; it is a question of dilution.

Q. Do you think the same result follows if you put sewage into a basin of water which is still and held by a dam as would follow if you put it into a freely moving body of water or stream? A. No; the effect of a dam is to make a greater dilution desirable, in order to prevent any noticeable effects from the sewage.

Q. Then, if you are going to put sewage into a body of water, it is better to have it stagnant than to have it put into a freely moving stream and carried away? A. I think you misunderstood me. It is better not to have sewers emptying in at all, if it can be prevented.

Q. Is your report based on the conditions after the dam is built, or have you considered it simply on the basis of the three driest months? A. We have considered it on the basis of the condition that would exist after the dam has been built. We have not taken into account the very large volume of water which would be there, and would have a purifying effect; while the existence of a dam might have an opposite and undesirable effect.

Q. What kind of a dam did you assume would be built? A. I assumed that a dam would be built there so as to keep the water constantly at grade 8, and I think it so states in the report.

Q. What becomes of the water after it is poured into a basin kept at a level such as that? A. That basin would have a tremendous amount of motion; in time of spring freshets it would be discharged twice a day, probably; in extreme freshets it would be emptied in the time of two

tides, in ordinary freshets perhaps once in two or three days or a week, and during other seasons there would be a great deal of motion. The winds create a motion, and there is, besides, going .to be a considerable current through that basin from the flow of the river.

Q. You have based your calculations on the entire absence of tide? A. Yes, sir; on the entire absence of tide.

Q. How would it be during the other months? A. The dry weather flow would be equivalent to changing the whole basin of water in about 80 days, — somewhat less than three months.

Q. Is it well recognized, or is it not, that the pollution of streams that passes through a basin like this would be deposited in the bottom? A. Heavy matters, sand and that sort of thing, might be deposited, but that I am not sure of; the flow of the stream might be sufficient to take those out. I think the chances are sand would deposit.

Q. Would you limit it to sand? A. I should limit it to sand. The other matters would undoubtedly decompose in time, and go off in the water.

Q. Your estimate as to the discharge into this stream is based upon the population as it now exists, or have you made allowances for the probable increase of population? A. We have considered the future probable increase, but it is based on the conditions which now exist and which will exist after the high-level system is built. But the changes that are now going on have been considered; the changes that are now going on are evidently going to take care of the discharge of sewage. The worst conditions would exist to-day, before the dam is built. Separate systems of sewers are being built through the district.

Q. I understood all that, but I wanted to know whether your figures of 2,400 are based on the present calculation of population, or on the future population? A. That is based on the present population.

Q. Is the population one in which the increase is rapid? A. Yes; the increase in population is likely to be quite rapid.

Q. Do you know what the increase has been in the last ten years, — the last decade? A. I have not the figures in mind, but I could give you the figures.

Q. Could you give us an idea, in your table of the increase in the last decade and your estimate, of the increase of population during the next decade? A. I can give you the increase in the last decade.

Q. If you have a basin which is kept permanently at

grade 8, is there any substantial current near the bottom of the stream? A. Well, if there is a current in the basin at all, of course there is a current all through it; that is, if there is a current in the basin, the current is at the surface and at the bottom. It would be less at the surface than it would be below the surface, and then it would probably decrease towards the bottom.

Q. Until within a foot of the bottom it is substantially sluggish, isn't it? A. No; I cannot say exactly what it would be.

Q. Do your calculations, Mr. Goodnough, contain the per cent. of pollution in the three driest months of the year? As I understand, you have a certain amount of sewage or polluting matter which is put into the stream, and you have a volume of current of water in the three driest months of 52 cubic feet per second? A. Yes, sir.

Q. What per cent. of pollution is in the water? A. I have not taken it that way.

Q. That is the ordinary way of computing the percentage of purity of water, isn't it? A. Not in percentages; it is computed on the probable dilution per thousand people.

Q. Supposing you wanted to get at the question of the purity of water supply, wouldn't you figure down to the percentages? A. No.

Q. I asked that question because I have observed at other hearings where other engineers have testified, in hearings which I have been carrying on for the last two years in regard to the purity of water supply, hydraulic engineers and civil engineers have done so, — they have given it in percentages. A. No; the question is not one of safety of water for the water supply.

Q. I suppose there is a percentage of impurity which will make its presence in water obnoxious to the public and dangerous to the public health? A. There is.

Q. Is there a well-recognized method of determining that? A. Yes, there is a method given in the reports of the Board of Health.

Q. Does that contain the degree of pollution — A. That contains the permissible degree of pollution in the water.

Q. How is it stated, — as a degree? A. As the quantity of sewage per thousand persons discharging into the stream in proportion to the flow.

Q. Then it is a question of computation to determine the percentage from that? A. Yes, sir.

Q. Could you, without much trouble, give us the degree and percentage of pollution in the stream in the three driest

months of the year? A. Yes, but that will be stated in the statement that the chairman has asked for as to the basis for the 2,400 people.

Q. Perhaps it will, but if we can get it in such form, so that we can tell what proportion there was, I presume we can call it proportion or per cent. Do you know anything about the malarial conditions of the river in the vicinity of this proposed basin? A. No; that has been gone into by the members of the Board. I have not made any examinations as to the malarial conditions.

Q. Has the Board any data upon that question? A. That I don't know; I think they have. It is a different department from mine.

Q. Do you suppose it would be possible for us to get that data? A. It would seem so, if you would send after it.

Mr. DUNBAR. I should like to have the permission of the committee to ask the State Board of Health for that.

Mr. GOODNOUGH. My impression is that that which relates to Charles River is published in one of the special reports of the Board.

Mr. DUNBAR. Yes. I ask that question because I see by the report of the Board of Health that in Cambridge last year there were 32 cases of malaria there, and I thought perhaps some such data would be valuable. Is it understood that the committee ask the State Board of Health to furnish that information?

Q. (by Mr. MATTHEWS). Mr. Goodnough, when you make up those figures which Mr. Dunbar has asked for respecting the flow during the three driest months, will you include the rest of the year as well as the dry months; and let me ask you now what you have concerning the flow of Charles River? A. The records I have just given here are based on the records of flow of the Sudbury River. The Sudbury River water-shed is adjacent to that of the Charles River. It is not feasible to make a measurement of the flow of the Charles River at the site of the proposed dam, it is complicated to such an extent by the flow of tide water.

Q. You have done what the engineers generally do in Massachusetts, — you have applied the records of the Sudbury River? A. Yes, I have applied the records of the Sudbury River in making my estimates.

Q. Then I wish you would supply figures showing the whole flow of the river, so as to give us the winter flow, the maximum flow, as well as the dry weather flow and the average also. Do you know whether there are any records at Watertown dam? A. I don't know of any. There may be some at Waltham dam.

Q. At any rate, the figures you have used are simply the Sudbury figures? A. The Sudbury figures.

Q. And you said that the calculation resulting in the figures 2,400, of which you are going to give us some details, are all constructed on the dry weather flow, and not on the cumulated water in this basin? A. That is so.

Q. Will this basin be in any sense a stagnant basin? A. Not at all.

Q. You said something about the effect of the wind upon it; that would be considerable, would it not, in a basin as shoal as this would be? A. Yes, decidedly.

Q. Decidedly? A. Very decidedly.

Q. You estimate that in a period of the driest flow, the driest minimum flow, the water in this basin would renew itself from the river itself in the basin in about 80 days? A. Yes.

Q. What is that result predicated upon. Is that predicated upon any particular type of dam, or is it not? A. No particular type of dam, except a dam that will allow the overflow to go through and keep out high tides.

Q. Any dam that will maintain a constant grade of 8 and allow sufficient overflows to carry down the fresh water? A. Exactly.

Q. And that estimate of 80 days is predicated upon the basin being completely filled with fresh water from above stream? A. It is; yes.

Q. If the lower strata should be filled with salt water from below the dam, that would considerably reduce the estimate of 80, would it not? A. Yes, it would very considerably reduce the estimate, if it should be filled from below with salt water.

Q. What would be the period required for an entire change of the water in the basin, assuming there would be no salt water above the dam in periods other than the dry weather? A. Well, it would change, as I say, — high freshets would change it in a day; but probably in ordinary times, in winter, — now I am guessing, — in about a week, I should say, — with ordinary flows about once in 20 days perhaps.

Q. And whenever any rains come such as cause any overflow of the present sewers into the river, the effect of those same rains would be to increase the rapidity with which the water would be changed? A. Yes, sir.

Q. The overflows of the sewers would be coincident with the increase in the stream? A. Yes.

Q. What experience or data are your calculations based on in reference to the amount of sewage that can be safely

introduced into a stream or body of water? A. The experience with streams of the State which has been reduced to a table and given in one of our reports, — the one which I mentioned to Mr. Dunbar a few moments ago.

Q. You did not give the reference to that report? A. No, I have it here. This is the report of the State Board of Health upon the examination of water supplies in 1890.

Q. That is the special report sent to the Legislature, is it? A. The special report of 1890, Part I., and the table to which I refer is given on page 789.

Q. Are the instances which were used for the formulation of this opinion of yours based upon data sufficiently similar to the Charles River basin to serve as a precedent? A. I think so; yes, sir.

Q. And you spoke of another report relating to malaria; will you indicate which one that was? A. I cannot give you the reference to that, but I will give it to you.

Q. It relates to malaria all over the State, or at the vicinity of this basin? A. This particular matter to which I referred relates to this particular vicinity, — as to malaria in Charles River basin.

Q. You find instances of malaria all over the State, don't you? A. Malaria has occurred in a great many places all over the State.

Q. Does the Charles River basin you referred to mean entirely above the proposed dam? A. No, it refers to this proposed region between Waltham and the mouth of the river.

Q. (by Mr. Dunbar). Have you any information that gives above the dam? A. Yes, I think there was one report published in 1896 which contains information as to the region further up.

Q. (by Mr. Matthews). Why won't you send a report to the secretary of the committee, suggesting all reports on malaria, not only on Charles River basin, but all through the State? A. Yes, I will do that.

Q. You spoke about the different methods adopted by hydraulic and other engineers in regard to the purity of water; in this case, is the reason for that difference that in water supply you ought not to have any sewage? A. Yes; as I understood Judge Dunbar's statement, he said that the percentages were estimated in such cases. My answer is that in regard to water supply the problem is the prevention of any pollution at all.

Q. (by Mr. Dunbar). Percentages to which I referred had been made with reference to determining whether it

should be used or not, because the case in which it arose was as to the pollution by a manufacturing establishment for making paper, and the kind of pollution; and the per cent. of pollution was determined for the purpose of determining the amount of damage arising in a stream used for manufacturing paper. A. Yes, the pollution from the sanitary point of view.

Q. (by Mr. MATTHEWS). So far as the public health would be affected. That is a different proposition from the other. A. That is a different proposition.

Q. You said in your calculations you had taken the per cent. of the population of the district in question, and that there would be an increase in future; and that you had not considered the effect of that increase, because, in your judgment, it would be affected by the changes in the drainage system; is that right? A. That is right.

Q. And you referred to the gradual extension of the separate system of drainage? A. Yes.

Q. That, you think, would fully offset the increase in population? A. That, in my opinion, would fully offset the increase in population.

Q. (by Commissioner DANA). You mean it would be necessary to increase the separate system as the population increased, in order to bring about good results? A. I mean to say that after this high-level system is completed the purpose is to take only sewage from separate systems into the high-level sewer in the future; and if that plan is continued, unless there is a change in the policy in the district and of the municipalities, the separate system is to be gradually increased throughout the Charles River area, and that would gradually bring about a condition of no sewage pollution of the river.

Q. (by Mr. MATTHEWS). That is to say, as I understand it, you had meant that the population in the outlying districts, the suburban sections of Cambridge and Boston, would increase? A. Yes, sir; that they would increase.

Q. But that it is in just those sections that the separate system would be put in, and one offsets the other? A. Yes.

Q. (by Commissioner DANA). If the separate system was not increased, and the population was increased, it might be serious? A. Yes, possibly in about twenty years from now. In forty years from now I don't know what would happen. Probably in that time, unless separate systems are put in, it will be necessary to put in some other system of main drainage.

Q. You spoke of "the health of persons bordering on this

basin;" did you also consider any question of the comfort or the discomfort of the people living in the vicinity of the basin, in those calculations? A. I think those questions would be included, — if there is a discomfort from odor; yes.

Q. (by Mr. MATTHEWS). When you refer to the necessity for the introduction of the separate system of sewers, you mean those areas which are not yet sewered, or in which the population would increase? A. Yes; I referred to the areas in which there are no sewers, or in which the population would increase.

Q. Whereas, if I understand you correctly, the condition of things in the Back Bay district is not going to be any better than at the present time? A. No, it is probably going to be better in that district if the plans of the street department are carried out.

Q. Speaking of the extension of the separate systems, isn't it the opinion of sanitary science generally that the separate systems should be carried out generally? A. That is, perhaps, a question. There are some cases, perhaps, in which the combined system may be admissible; but in this section the separate system is best, because it is most economical. Pumping rain water to Moon Island is unnecessary; the separate system will get rid of the necessity for carrying such water to Moon Island.

Q. Whether or not the separate system and the introduction of it generally is not considered necessary or advisable, entirely apart from the construction of his dam? A. It undoubtedly is.

Q. (by the CHAIRMAN). The lowest dam at present is the Watertown dam, is it not? A. Yes.

Q. What is the length of the basin above, between that and the next dam, approximately? A. I can only guess; I should say perhaps half a mile.

Q. Half a mile? A. Yes.

Q. Is the condition with respect to the pollution approximately the same that would hold with respect to this basin? A. Not exactly. At the present time the basin above the Watertown dam receives no sewage overflow; this proposed basin now does receive some. After the dam is built, the condition of this basin would, I think, be about the same as that of basins above. I see no very material difference, the quantity of sewage discharging into the proposed basin would be so small after the construction of the high-level sewer.

Q. The purity of the water here would be about the same as in the basin above, would it? A. It would.

OFFICE OF STATE BOARD OF HEALTH, STATE HOUSE,
BOSTON, MASS., Feb. 26, 1902.

DR. HENRY S. PRITCHETT, *Chairman of Committee on Charles River Dam, 14 Beacon Street, Boston, Mass.*

DEAR SIR: — I send you herewith a statement in detail of the calculations as to the quantity of sewage discharging into Charles River and likely to be discharged into that stream after the high-level sewer is completed.

It has been assumed in these calculations that the Talbot Avenue district, so called, is provided with sewers on the combined plan, and will continue to have a combined system in the future. I have since been informed that works are now under construction in the Talbot Avenue district, which, when completed, will separate the sewage from the storm water in a considerable area. If allowance should be made for the proposed change in that district, the estimated population discharging sewage into Charles River would be somewhat less than the figures given in the appended estimates.

MEMORANDUM OF ESTIMATED QUANTITY OF SEWAGE DISCHARGED INTO CHARLES RIVER ABOVE THE PROPOSED DAM NEAR CRAIGIE BRIDGE, AND THE PROBABLE DILUTION OF THE SEWAGE.

It is assumed that the proposed dam would be located between Craigie and West Boston bridges, approximately at the location indicated in the report of the Joint Board in 1894.

The proposed dam at the location indicated would create a basin about 8½ miles long, having an area of 790 acres and a capacity of 3,000,000,000 gallons.

The sewage of Cambridge, on the north side of the proposed basin, is discharged into a branch of the north metropolitan system, but a portion of it, mingled with storm water, overflows into Charles River at times of storms. The sewage from Watertown and Waltham, on the northerly side of the river above Cambridge, and from Newton, Brighton, Brookline and the Back Bay district of Boston, together with the sewage from the westerly side of the city bordering Charles River and the valley of Stony Brook, one of its tributaries, is discharged into the main drainage system of the city of Boston. The sewers of Waltham and Watertown, on the northerly side of the river, and of Newton on the southerly side, are constructed upon the so-called separate plan, sewage only being received into the sewers, while drains are provided for removing the storm water, which is discharged into the river or into local water courses. There are also considerable areas of separate sewers in Brighton, Brookline and the Back Bay district of Boston. The remaining areas in Brighton, Brookline and Boston draining toward the Charles River are provided with sewers on the combined plan, and a portion of the sewage and storm water is discharged into the river or its tributaries at times of storms.

The total sewered area in Cambridge discharging storm water above the proposed dam is 3.3 square miles, including the areas already provided with separate sewers in this district. The total area of combined sewers in Brighton, Brookline and Boston, on the southerly side of the river discharging storm water above the proposed dam, is 9.4 square miles. In addition to the sewage entering the river from overflows from combined systems of sewers, the sewage of about 1,000 people enters the river directly at all times from houses along Beacon Street in Boston, and it is said that some sewage also enters the Stony Brook channel in Roxbury at the present time.

The Boston main drainage system, into which the sewage from combined systems of sewers along the south side of the Charles River discharges, has three principal tributaries in the area draining toward Charles River. These are: —

1. The Charles River valley intercepting sewer.
2. The west side intercepting sewer.
3. The Stony Brook intercepting sewer.

The Stony Brook intercepting sewer is a comparatively short sewer, and is without overflow or connection from its upper end to the main sewer. At the upper end of the Stony Brook sewer there is a district regulator, so called, located in the intercepting sewer itself, which regulates the quantity of sewage that can enter it. The regulator is planned to be set so that about 25,000,000 gallons per day can flow through this sewer into the Boston main drainage works. The area at present provided with sewers tributary to the Stony Brook intercepting sewer is 4.4 square miles, and the population on this area is approximately 94,000. Assuming that the average quantity of sewage contributed by each person is 75 gallons, the total quantity of sewage flowing in this sewer in dry weather would be about 7,000,000 gallons per day. This sewer is consequently able to carry 18,000,000 gallons per day of storm water, equivalent to a run-off of about .24 of an inch per day, or .01 of an inch per hour.

The capacity of the Boston main drainage system as at present developed is 122,000,000 gallons per day, and when developed as far as practicable will be about 154,000,000 gallons per day. The dry weather flow of sewage in 1900, as indicated by the pumping records, was about 60,000,000 gallons per day, and the capacity for storm water in the drier portion of the year is 62,000,000 gallons per day. The Stony Brook interceptor contributes 18,000,000 gallons of storm water, so that the capacity for storm water from the remainder of the district, exclusive of the Stony Brook district, is 44,000,000 gallons per day. The total area of combined sewers, excluding the Stony Brook valley district, tributary to the main drainage system, is about 16.8 square miles; and the quantity of storm water that can be removed at present by the main drainage works from this area is .15 of an inch per day, or .0063 of an inch per hour.

The sewage of Cambridge is removed by the north metropolitan sewerage system through a branch sewer, having a capacity, where the last overflow above Craigie bridge is located, of 40,000,000 gallons per day. The metropolitan sewer is, however, provided with a regulator, which reduces the capacity to 27,000,000 gallons. The estimated population on the district tributary to this sewer is 82,000. Assuming the dry weather flow of sewage from this population as 75 gallons per person, the total dry weather flow would be 6,150,000 gallons per day, leaving a capacity for storm water of 20,850,000 gallons per day. The sewer drains a district of 3.3 square miles, nearly all of which is provided with sewers upon the combined plan; and the storm water run-off which is provided for under these conditions is equivalent to a depth of .37 of an inch per day, or .015 of an inch per hour on the tributary water-shed.

The quantity of sewage which would discharge through the storm overflows depends upon the rate of rainfall and the proportion reaching the sewers. Definite information as to the rate of rainfall in this neighborhood is available from the records which have been kept at Chestnut Hill for several years by Mr. Desmond FitzGerald, engineer of the Sudbury division of the metropolitan water works, and at Cambridge by Mr. L. M. Hastings, city engineer. Using this data, and assuming that one-half the rainfall reaches the sewers within the time

in which it falls, which is probably a worse condition than actually occurs, it is practicable to calculate the quantity of overflow from the sewers in the districts under consideration in different months in several years.

The quantity of sewage overflowing through the storm overflows is dependent very largely upon the depth of rainfall, because in cities the surfaces upon which the rain falls are largely impervious, and a large proportion of the rain runs off the surface quickly into the streams or sewers at all seasons of the year. The flow of the stream, on the other hand, varies very greatly in different portions of the year, because, while in winter the rain or melting snow flows off the ground rapidly into the streams, in summer a very large proportion of the rain is held by vegetation and lost by evaporation, and only a very small proportion reaches the streams, in comparison to the proportion of rainfall which reaches them in the winter and spring.

In order to determine the conditions under which the greatest probable discharge of sewage from storm overflows would occur and the least probable dilution of the sewage, studies have been made of the probable quantity of sewage discharged into the stream and the probable flow of water in the river at different seasons in several years.

It is obviously necessary, in order to obtain a fair estimate of the probable dilution, to take a period of considerable length; since there are, of course, periods of several weeks when there is little or no rainfall, and consequently no overflow from a combined system of sewerage. The capacity of the proposed basin is such that the flow of the river in a very dry season would serve to change the water in a little less than once in three months, and a period of three months has been selected in estimating the probable dilution of the sewage.

The results of these studies show that the greatest quantity of sewage discharged into the basin in three months (excluding the winter months, when calculations were obviously impracticable) in the years selected for study occurred in the months of September, October and November, 1895, when a quantity equivalent to the sewage of 12,450 persons was discharged into the basin, including the discharge from houses on Beacon Street. The dilution was, however, equivalent to more than 40 cubic feet per second per 1,000 persons. The above quantity, 40 cubic feet per second per 1,000 persons, is equivalent to a dilution (assuming that each person contributes 75 gallons of sewage per day) of 345 to 1. A similar estimate shows that in May, June and July, 1893, the quantity of sewage discharged through overflows was probably as much as would be contributed by 8,600 people discharging sewage continuously; but the flow of the stream was about 52 cubic feet per second per 1,000 persons, equivalent to a dilution of 450 to 1.

On the other hand, taking the three months in each year having the least flow in the stream, it is found that, while the probable quantity of sewage discharged into the river is smaller than in wet months, the flow of the stream is at the same time very much smaller than in wet months, and the consequent dilution of the sewage much less than in months when the quantity of sewage discharging is higher.

In this way it has been found that the three months of July, August and September, 1900, probably represent the condition of least dilution of the sewage discharged into the basin of any three months within the past twenty-seven years. The quantity of sewage discharged into the basin in the three driest months of 1900 has been estimated as shown in the following tables: —

TABLE I. — *Total Number of Hours during which Precipitation occurred at Certain Rates during the Months of July, August and September, 1900.*

MONTHS.	Rate, in Inches per Hour.													
	.0 to .015.	.015 to .025.	.025 to .035.	.035 to .05.	.05 to .075.	.075 to .1.	.1 to .15.	.15 to .2.	.2 to .3.	.3 to .4.	.4 to .5.	.5 to 1.	1 to 2.	Over 2.
July,	3.2	-	8.3	6.9	-	2.7	1.8	-	2.5		.4	.3		.1
August,	26.2		-	-	-		-	1.2	2.0	.3	-	-	.6	.4
September,	5.3	3.0	6.3	1.2	3.6	3.7	3.4	.2	3.9	.7	2.2	.9	-	-
Totals,	34.7	3.0	14.6	8.1	3.6	6.4	5.2	1.4	8.4	1.0	2.6	1.2	.6	.5

TABLE II. — *Quantity of Sewage overflowing into Charles River and its Tributaries from the Boston Main Drainage and the Charles River Valley Metropolitan Districts, excluding the Stony Brook District.*

Capacity of main drainage system (gallons per day),	122,000,000
Capacity of main drainage system (gallons per hour),	5,083,000
Sewer receives rain water, 18,000,000 gallons, and sewage, 7,000,000 gallons, from the Stony Brook district (total gallons per day),	25,000,000
Sewer receives rain water and sewage from the Stony Brook district (gallons per hour),	1,040,000
Sewer receives sewage from main drainage system, excluding the Stony Brook district (gallons per day),	53,000,000
Sewer receives sewage from main drainage system (gallons per hour),	2,210,000
Total population of main drainage district,	603,000
Population of portion of district tributary to Charles River, excluding Stony Brook,	151,000
Sewage from the main drainage system and sewage and rainfall from Stony Brook together equal (gallons per hour),	3,250,000
Capacity of main drainage system for storm water from its own district, without overflowing (gallons per hour),	1,833,000
Equivalent, on 16.8 square miles, to 109,000 gallons per square mile, or to .0068 of an inch per hour.	

The percentage of sewage overflowing is —

$$100 \times \left(1.00 - \frac{5{,}083{,}000}{\text{Rainfall at one-half rate at which it is falling per hour (in gallons).} + 3{,}250{,}000}\right)$$

Rate of Rainfall (Inches per Hour). — Table 1.	Total Number of Hours at Given Rate, July to September, 1900.	Percentage of Sewage overflowing.	Equivalent to All Sewage discharging for —
			Hrs.
.000- .015	34.7	-	.0
.015- .025	3.0	17	.5
.025- .035	14.6	33	4.8
.035- .050	8.1	46	3.7
.050- .075	3.6	59	2.1
.075- .100	6.4	68	4.3
.100- .150	5.2	76	3.9
.150- .200	1.4	83	1.1
.200- .300	8.4	87	7.3
.300- .400	1.0	91	.9
.400- .500	2.6	93	2.4
.500-1.000	1.2	95	1.1
1.000-2.000	.6	-	.6
Over 2.000	.5	-	.5

Total number of hours of overflow,	33.2
Percentage of the total number of hours in the three months from July to September, 1900,	1.5
Equivalent, in a population of 151,000, to a constant discharge from 2,270 people.	

TABLE III. — *Quantity of Sewage overflowing into Stony Brook, a Tributary of Charles River, from Sewers in the Valley of Stony Brook.*

Capacity of Stony Brook sewer, regulated (gallons per day), . . .	25,000,000
Capacity of Stony Brook sewer, regulated (gallons per hour), . . .	1,040,000
Population of district tributary to this sewer, ...	94,000
Quantity of sewage at 75 gallons per head (gallons per day), ...	7,000,000
Quantity of sewage at 75 gallons per head (gallons per hour), . . .	292,000
Capacity for storm water, without overflowing (gallons per hour), . .	748,000
Equivalent, on 4.4 square miles, to 170,000 gallons per square mile, or to .0098 of an inch per hour.	

The percentage of sewage overflowing is: —

$$100 \times \left(1.00 - \frac{1{,}040{,}000}{\text{Rainfall at one-half rate at which it is falling per hour (in gallons).} + 292{,}000}\right)$$

NOTE. — Capacity of sewer could be increased by changing regulator.

Rate of Rainfall (Inches per Hour). — Table I.	Total Number of Hours at Given Rate, July to September, 1900.	Percentage of Sewage overflowing.	Equivalent to All Sewage discharging for —
			Hrs.
.000- .015	34.7	-	.0
.015- .025	3.0	-	.0
.025- .035	14.6	27	3.9
.035- .050	8.1	45	3.6
.050- .075	3.6	61	2.2
.075- .100	6.4	71	4.5
.100- .150	5.2	79	4.1
.150- .200	1.4	85	1.2
.200- .300	8.4	90	7.6
.300- .400	1.0	92	.9
.400- .500	2.6	94	2.4
.500-1.000	1.2	96	1.2
1.000-2.000	.6	-	.6
Over 2.000	.5	-	.5

Total number of hours of overflow, ...	32.70
Percentage of the total number of hours in the three months from July to September, 1900, ...	1.48
Equivalent, in a population of 94,000, to a constant discharge from 1,390 people.	

TABLE IV. — *Quantity of Sewage overflowing into Charles River from Cambridge Sewers.*

Capacity of Cambridge metropolitan sewer, regulated, as at present (gallons per day), ...	27,000,000
Capacity of Cambridge metropolitan sewer, regulated (gallons per hour), .	1,125,000
Population of district tributary to this sewer, ...	82,000
Quantity of sewage at 75 gallons per head (gallons per day), ...	6,150,000
Quantity of sewage at 75 gallons per head (gallons per hour), . . .	256,000
Capacity for storm water, without overflowing (gallons per hour), . .	869,000
Equivalent, on 3.3 square miles, to 263,000 gallons per square mile, or to .015 of an inch per hour.	

The percentage of sewage overflowing is: —

$$100 \times \left(1.00 - \frac{1{,}125{,}000}{\text{Rainfall at one-half rate at which it is falling per hour (in gallons).} + 256{,}000}\right)$$

NOTE. — Capacity of Cambridge sewer, unregulated, is 40,000,000 gallons per day.

Rate of Rainfall (Inches per Hour).— Table I.	Total Number of Hours at Given Rate, July to September, 1900.	Percentage of Sewage overflowing.	Equivalent to All Sewage discharging for —
			Hrs.
.000- .015	34.7	-	.0
.015- .025	3.0	-	.0
.025- .035	14.6	-	.0
.035- .050	8.1	24	1.9
.050- .075	3.6	45	1.6
.075- .100	6.4	59	3.8
.100- .150	5.2	70	3.6
.150- .200	1.4	78	1.1
.200- .300	8.4	85	7.1
.300- .400	1.0	89	.9
.400- .500	2.6	91	2.4
.500-1.000	1.2	95	1.1
1.000-2.000	.6	-	.6
Over 2.000	.5	-	.5

Total number of hours of overflow, ... 24.6
Percentage of the total number of hours in the three months from July to September, 1900, ... 1.1
Equivalent, in a population of 82,000, to a constant discharge from 900 people.

Bringing together the results of the foregoing estimates, it is found that the quantity of sewage discharged under present conditions into the Charles River above the proposed dam is approximately as follows in a time of extremely low flow in the stream: —

	People.
From the Boston main drainage district, exclusive of Stony Brook, . .	2,270
From the Stony Brook district, ...	1,390
From the Cambridge district, ...	900
From the rear of Beacon Street, ...	1,000
Total, ...	5,560

At 75 gallons of sewage per person, the total estimated quantity of sewage discharging into the basin would be (gallons per day), ... 417,000

Estimated Flow of Charles River just above Craigie Bridge in the Months of July, August and September, 1900.

Total water-shed of river at Craigie bridge (square miles), ...		305.0
Allowance for diversion of one-third of water-shed above Mother Brook (square miles), ...	66.0	
Area of water-shed diverted by the city of Cambridge (square miles), .	22.9	
Area of water-shed diverted by the town of Concord (square miles), .	.6	
Total water-shed diverted (square miles), ...		89.5
Net water-shed of Charles River at point above Craigie bridge (square miles), ...		215.5

Estimated yield in cubic feet per second per square mile, ...	.276	
Estimated yield in cubic feet per second of water-shed of 215.5 square miles, ...	59.5	
Quantity of water in cubic feet per second brought into the water-shed by public water supplies, ...	33.9	
Total in cubic feet per second, ...		93.4
Quantity of water in cubic feet per second taken out by public water supplies, ...	.53	
Quantity of water in cubic feet per second taken out by sewers, . .	32.97	
		33.5
Total estimated flow in cubic feet per second of river at proposed dam, ...		59.9

Summary.

Flow of river in cubic feet per second per 1,000 persons discharging into river,	10.8
Flow in cubic feet per second per 1,000 persons discharging into river, excluding houses on Beacon Street,	13.1
Total daily flow of river in gallons,	38,700,000
Total daily flow of sewage in gallons,	417,000
Ratio of sewage to river water,	1 to 93
Ratio of sewage to river water, excluding houses on Beacon Street,	1 to 113

The degree of dilution which has been found necessary to prevent unsanitary conditions where sewage is discharged into a stream, assuming 75 gallons of sewage per person, ranges between 20 to 1 and 60 to 1. In estimating the degree of dilution of the sewage, no account has been taken of the purifying effect of the water of the basin itself.

A depth of 1 inch on the surface of the basin formed by the proposed dam, with the water in the basin at grade 8, would contain 21,500,000 gallons, which is equivalent to 33.2 cubic feet per second for twenty-four hours. The dry weather flow, about 60 cubic feet per second, would be equivalent to 1.8 inches on the basin in twenty-four hours, or about 1 inch during each tide. By allowing 1 inch of salt water to enter the basin each day, or ½ inch at each high tide, the average flow out of the basin could be increased to 93 cubic feet per second.

The following table gives the average flow in twenty-four hours out through the dam which could be maintained at the times of the lowest flow in the river by the admission of different quantities of salt water, including the flow of the river: —

Depth of Salt Water permitted to enter the Basin (Inches per Day).	Average Flow of River (Cubic Feet per Second).	Depth of Salt Water permitted to enter the Basin (Inches per Day).	Average Flow of River (Cubic Feet per Second).
1	93	7	292
2	126	8	326
3	160	9	359
4	193	10	392
5	226	11	425
6	259	12	458

Estimate of Quantity of Sewage that will discharge into the Charles River and its Tributaries after the High-level Sewer is completed.

When the high-level sewer is completed, and connections made with the sewers from the districts which it is proposed to make tributary to this sewer, the area of the combined sewers tributary to the main drainage system, exclusive of Stony Brook, will be reduced from 16.8 square miles to 9.6 square miles. The areas provided with sewers on the combined system in the valley of Stony Brook which are tributary to the main drainage system will be reduced from 4.4 square miles to about 2.4 square miles. There will be tributary to the high-level sewer about 9.2 square miles of areas provided with sewerage upon the combined plan.

In the following tables the quantity of sewage which will overflow into Charles River and its tributaries from combined systems of sewers is estimated in a manner similar to that used in making the tables already given: —

TABLE V. — *Quantity of Sewage that will overflow into Charles River and its Tributaries from the Boston Main Drainage District, excluding the Stony Brook District, after the High-level Sewer is completed.*

Capacity of main drainage system (gallons per day),	122,000,000
Capacity of main drainage system (gallons per hour),	5,083,000
Total population of main drainage district,	341,000
Population of district tributary to Charles River, excluding Stony Brook,	38,000
Sewer will receive sewage from Stony Brook (gallons per day),	4,500,000
Sewer will receive rain water from Stony Brook (gallons per day),	20,500,000
Sewer will receive rain water from Stony Brook (gallons per hour),	850,000
Sewer will receive sewage, including Stony Brook but excluding high-level districts (gallons per day),	36,000,000
Sewer will receive sewage (gallons per hour),	1,500,000
Total flow of sewage from main drainage district and of sewage and rainfall from Stony Brook, taken together (gallons per hour),	2,350,000
Capacity for storm water, without overflowing (gallons per hour),	2,730,000
Equivalent, on 9.6 square miles, to 280,000 gallons per square mile, or to .016 of an inch of rain per hour.	

The percentage of sewage overflowing will be: —

$$100 \times \left(1.00 - \frac{5,083,000}{\text{Rainfall at one-half rate at which it is falling per hour (in gallons).} + 2,350,000}\right)$$

Rate of Rainfall (Inches per Hour). — Table I.	Total Number of Hours at Given Rate, July to September, 1900.	Percentage of Sewage overflowing.	Equivalent to All Sewage discharging for —
			Hrs.
.000- .015	34.7	-	.0
.015- .025	3.0	-	.0
.025- .035	14.6	-	.0
.035- .050	8.1	15	1.2
.050- .075	3.6	34	1.2
.075- .100	6.4	48	3.1
.100- .150	5.2	60	3.1
.150- .200	1.4	70	1.6
.200- .300	8.4	78	6.6
.300- .400	1.0	84	.8
.400- .500	2.6	88	2.3
.500-1.000	1.2	92	1.1
1.000-2.000	.6	-	.6
Over 2.000	.5	-	.5

Total number of hours of overflow,	21.50
Percentage of the total number of hours in the three months from July to September, 1900,	.97
Equivalent, in a population of 38,000, to a constant discharge from 370 people.	

TABLE VI. — *Quantity of Sewage that will overflow into Stony Brook, a Tributary of the Charles River, from Sewers in the Valley of Stony Brook, after the High-level Sewer is completed.*

Capacity of Stony Brook sewer, regulated (gallons per day),	25,000,000
Capacity of Stony Brook sewer, regulated (gallons per hour),	1,040,000
Population of district tributary to Stony Brook sewer,	59,000
Quantity of sewage at 75 gallons per head (gallons per day),	4,500,000
Quantity of sewage at 75 gallons per head (gallons per hour),	190,000
Capacity for storm water, without overflowing (gallons per hour),	850,000
Equivalent, on 2.4 square miles, to 350,000 gallons per square mile, or to .021 of an inch of rain per hour.	

The percentage of sewage overflowing will be: —

$$100 \times \left(1.00 - \frac{1,040,000}{\text{Rainfall at one-half rate at which it is falling per hour (in gallons).} + 190,000}\right)$$

Rate of Rainfall (Inches per Hour). — Table I.	Total Number of Hours at Given Rate, July to September, 1900.	Percentage of Sewage overflowing.	Equivalent to All Sewage discharging for —
			Hrs.
.000– .015	34.7	-	.0
.015– .025	3.0	-	.0
.025– .035	14.6	-	.0
.035– .050	8.1	5	.4
.050– .075	3.6	31	1.1
.075– .100	6.4	49	3.1
.100– .150	5.2	63	3.3
.150– .200	1.4	73	1.0
.200– .300	8.4	81	6.8
.300– .400	1.0	86	.9
.400– .500	2.6	89	2.3
.500–1.000	1.2	93	1.1
1.000–2.000	.6	-	.6
Over 2.000	.5	-	.5

Total number of hours of overflow, ... 21.1
Percentage of the total number of hours in the three months from July to September, 1900, ...96
Equivalent, in a population of 59,000, to a constant discharge from 560 people.

TABLE VII. — *Quantity of Sewage that will overflow into Charles River and its Tributaries from the South Metropolitan District, after the High-level Sewer is completed.*

Capacity of high-level sewer (gallons per day), ... 304,000,000
Capacity of high-level sewer (gallons per hour), ... 12,670,000
Population of area tributary to high-level sewer, ... 261,500
Population of district tributary to Charles River, ... 148,000
Quantity of sewage at 75 gallons per head (gallons per day), ... 19,500,000
Quantity of sewage (gallons per hour), ... 810,000
Capacity for storm water, without overflowing (gallons per hour), . . 11,860,000
Equivalent, on 9.2 square miles, to 1,290,000 gallons per square mile, or to .074 of an inch of rain per hour.

The percentage of sewage overflowing will be: —

$$100 \times \left(1.00 - \frac{12,670,000}{\text{Rainfall at one-half rate at which it is falling per hour (in gallons).} + 810,000}\right)$$

Rate of Rainfall (Inches per Hour). — Table I.	Total Number of Hours at Given Rate, July to September, 1900.	Percentage of Sewage overflowing.	Equivalent to All Sewage discharging for —
			Hrs.
.000– .015	34.7	-	.0
.015– .025	3.0	-	.0
.025– .035	14.6	-	.0
.035– .050	8.1	-	.0
.050– .075	3.6	-	.0
.075– .100	6.4	-	.0
.100– .150	5.2	-	.0
.150– .200	1.4	15	.2
.200– .300	8.4	39	3.3
.300– .400	1.0	56	.6
.400– .500	2.6	66	1.7
.500–1.000	1.2	79	1.0
1.000–2.000	.6	90	.5
Over 2.000	.5	-	.5

Total number of hours of overflow, ... 7.80
Percentage of the total number of hours in the three months from July to September, 1900, ...35
Equivalent, in a population of 148,000, to a constant discharge from 520 people.

Bringing together the results of the foregoing estimates, it is found that the quantity of sewage that will be discharged into the Charles

River above the proposed dam after the high-level sewer is completed will be approximately as follows in a time of low flow in the river: —

	People.
Boston main drainage district,	370
Stony Brook district,	560
South metropolitan district,	520
Cambridge district,	900
Houses along Beacon Street,	1,000
Total equivalent population discharging sewage continuously into Charles River after the completion of the high-level sewer,	3,350

Summary.

At 75 gallons of sewage per person, the total quantity of sewage discharging into the basin would be (gallons per day),	251,250
Taking the flow of the stream, as before, at 59.9 cubic feet per second, the flow of the river in cubic feet per second per 1,000 persons discharging sewage would be,	17.9
Excluding population in houses on Beacon Street, the total population discharging continuously into Charles River would be,	2,350
Equivalent quantity of sewage (gallons per day),	176,000
Flow of river in cubic feet per second per 1,000 persons so discharging,	25.3
Total daily flow of river (gallons),	38,700,000
Ratio of sewage to river water,	1 to 154
Ratio of sewage to river water, excluding the houses on Beacon Street,	1 to 218

The assumptions which have been made in the foregoing estimates, in my judgment, make the amount of sewage entering the basin in the dry time greater than the actual amount, particularly in the period after the completion of the high-level sewer, which period will begin before the dam can be built.

Estimate of the Approximate Quantity of Sewage that might, under Certain Conditions, be discharged into the Proposed Charles River Basin or its Tributaries in 1920.

An estimate has also been prepared of the quantity of sewage which might be discharged from overflows into the Charles River above the proposed dam in the year 1920.

It has been assumed, in making this estimate, that no changes will be made in the areas served either by separate or combined systems of sewers at the present time, so that, under this assumption, the separation of the sewage from the storm water now going on in the districts served by combined systems would cease at once. It is also assumed that all extensions into territory not now provided with sewers would be made upon the separate plan, as required by law, and that the population of the Boston main drainage and south metropolitan districts will increase from the present number, 604,166, to a total of 1,015,800 in 1920. Furthermore, it has been assumed that the Cambridge branch of the north metropolitan sewerage system will continue to be regulated as at present; that is to say, that the sewer will carry 27,000,000 gallons, though its full capacity is 40,000,000 gallons.

On this basis the total quantity of sewage that would be discharged into the river in 1920 would be equivalent to a constant discharge of sewage from a population of about 4,280, excluding the houses along Beacon Street.

The extensions of sewers in districts provided with sewerage systems in the lower part of the valley will have a tendency to reduce the flow of the river in the future; but, on the other hand, the quantity of water drawn from the valley for water supply purposes is likely to be materially reduced. Under the circumstances, it seems likely that the flow of the stream in the drier portion of a dry year will not be materially changed from its flow at the present time.

Conditions which will exist after 1920.

The north metropolitan system of sewerage was designed to serve until 1930, when it was expected, at the time the system was designed, that its capacity would be reached, and further provision for the removal of the sewage of this district would have to be made. Areas have been added to the district which were not included in the original plan, and this will have a tendency to lessen the length of time for which the system will serve. On the other hand, the separation of the sewage from the storm water in the district served by combined sewers will tend to increase the length of time during which this system will be adequate for the north metropolitan district.

The high-level system was designed to serve until 1940, and when this system was designed it was expected that the relief afforded by it to the Boston main drainage system would enable the latter to serve the low areas in Boston for an equal length of time. The separation of the sewage from the storm water in the south metropolitan and Boston main drainage districts will tend to prolong the time within which the systems in those districts also will provide adequately for the removal of the sewage.

Under the circumstances, it is not practicable to estimate the conditions which will exist in these districts beyond 1920.

It seems probable, from present indications, that the continuation of the work now being carried on of separating the sewage from the storm water within the metropolitan and Boston main drainage districts will, before many years, prevent the necessity for the discharge of any sewage into Charles River through storm overflows.

Population.

The estimated population within the water-shed of the proposed basin in the metropolitan district in 1900 and the estimated population in 1920 are submitted, in accordance with a request of the committee: —

Estimated population in 1900 on territory within the water-shed of Charles River in the cities and towns of Boston, Brookline, Newton, Cambridge, Watertown, Waltham, Arlington and Lexington,	381,450
Estimated population of same district in 1920,	611,500

Flow of Charles River for 1900.

The calculated flow of the Charles River for 1900 is appended, as requested. The flow of the stream for that year, judging from the records of flow of the Sudbury River, was about the average for the last twenty-six years. The flow during the summer and early autumn was exceptionally low, and during the late winter and in the spring exceptionally high.

Calculated Flow of Charles River for the Year 1900, at Craigie Bridge.

MONTHS.	Total for Month (Million Gallons.)	Million Gallons per Day.	Cubic Feet per Second.
January,	5,019	161	250
February,	22,981	821	1,270
March,	25,765	831	1,288
April,	9,908	330	510
May,	10,149	327	506
June,	2,837	95	146

Calculated Flow of Charles River for the Year 1900, etc. — Concluded.

MONTHS.	Total for Month (Million Gallons).	Million Gallons per Day.	Cubic Feet per Second.
July, August, September,	3,560*	38.7†	59.9†
October,	1,214	39	61
November,	3,951	132	204
December,	7,502	242	375

* Total for three months. † Average for three months.

Capacity of basin (million gallons), ... 3,000

The flow of the river during the year would be sufficient to change the water in the basin thirty-one times, or once in twelve days. In February and March the flow would be sufficient to change the water in the basin once in four days; in July, August and September, once in about seventy-eight days.

The following is a list of reports relative to malaria contained in the reports of the State Board of Health: —

	Page
Supplement to report of State Board of Health, Lunacy and Charity for 1880,	47
Supplement to report of State Board of Health, Lunacy and Charity for 1885,	3
Report of State Board of Health for 1888,	xlix
Report of State Board of Health for 1889,	247
Report of State Board of Health for 1896,	xvii
Report of State Board of Health for 1897,	xix
Report of State Board of Health for 1898,	113
Report of State Board of Health for 1900,	xxv
Report on Improvement of Charles River, 1896,	21
Report on Concord and Sudbury Rivers (House Document, No. 1380), 1901,	47, 56

Respectfully submitted, X. H. Goodnough,
Chief Engineer.

The following report from the Boston Park Commission was then read: —

Board of Commissioners of the Department of Parks,
Boston, Jan. 15, 1902.

Committee on Charles River Dam.

Gentlemen: — The park department of the city of Boston is interested in the question of this dam principally because of Stony Brook, the overflow of which enters the Fens, the remainder being carried through to the Charles River at Charlesgate. Sewage and filth are carried down by this brook, some of which is deposited in the basin of the Fens. This basin of the Fens is scoured by the introduction, at Brookline Avenue, of the water from the Charles River twice a day at high tide.

If the proposed dam should be placed below Charlesgate, it would be necessary to have all the deposit from Stony Brook cleaned out of the basin of the Fens, and the entire flow of Stony Brook carried to Charles River through a larger conduit than the one now maintained.

If the dam should be placed above Charlesgate and below Brookline Avenue, for the purpose of scouring the Fens' basin it would be necessary that the water of the river above the dam should be kept at such a height as would allow the water to flow freely through the conduit at Brookline Avenue into the Fens.

A dam placed above Brookline Avenue would have no appreciable effect upon any of our park lands or waters.

Yours respectfully, Chas. E. Stratton,
Chairman.

Mr. C. E. PUTNAM, assistant engineer of the Boston park department [referring to map on the wall prepared by the Boston park department]. This map shows the storm overflows into Stony Brook, and shows also a proposed conduit which it is proposed to build to take some of the dirtiest flow from Stony Brook without turning it directly into the pond. That is about all there is. We have no other plans. The flow of Stony Brook is ordinarily very small. This is simply a picture which shows what the Stony Brook is liable to become some time, and shows what the outlet is that is provided near Beacon Street. These two streams come directly from the Fens Pond; and these represent the tide gates, of which each one is 12 feet long by 7½ feet high; and these channels are the proposed outlets for the foul flow of Stony Brook, — what we call the foul flow, — that is, the first flow after the beginning of a storm, and they are made large enough to take the whole flow of Stony Brook, excepting in very severe storms.

Q. (by Mr. DUNBAR). There is only one question, Mr. Putnam. I asked some one who was here the other day about the filling up in the Fens where the Stony Brook came in there; can you tell us about that? A. There is a deposit of mud in the Fens.

Q. Has it been taken out? A. It was partly dredged out; only half of it was taken out.

Q. Has it filled up again? A. Some of it; yes.

Q. Where is that point? A. That is at the outlet of Stony Brook, near Huntington Avenue.

Q. Can you show me where that is on the map? A. Yes, here it is [pointing on the map].

Q. When was that dredged out? A. In 1898.

Q. It is now substantially filled up again as it was before? A. I don't think it is; no, sir. It is partly filled up, but I don't think it is anything like it was before.

Q. What is the depth there? A. The depth of water?

Q. Yes. A. The depth of water is, I think, an average of 5½ feet over the mud.

Q. At the shallowest point? A. No; at the shallowest point I don't think it is over 3.

Q. Is there a circulation of water maintained through that basin in the Fenway? A. Is there now?

Q. Yes. A. Yes.

Q. How do you maintain it? A. There is a conduit at the upper end of the Fens, known as Muddy River conduit; and we bring the water from the Charles River through this conduit at high tide, and at low tide it flows out at Beacon Street.

Q. Why do you do that? A. To prevent any trouble from this deposit in the Fens.

Q. Is that necessary? A. It is; yes, sir.

Q. It is necessary? A. Yes, sir; it might not be necessary if the pond was cleaned out, but it is a pretty difficult place to get at to clean out.

Q. Will that be feasible if the Charles River basin is maintained at a permanent grade 8? A. What? To allow a good circulation from the river?

Q. To make your circulation in that way. A. No, sir.

Q. It will not? A. Except by pumping.

Q. (by Mr. MATTHEWS). Mr. Putnam, suppose you had a rise and fall of a foot in the basin, would that give you a circulation? A. If the dam should be so managed that the water in the river could be caused to rise and fall, we could get the same rise and fall in the pond.

Q. How much of a rise and fall would be necessary to get that circulation? A. Well, we could get whatever rise and fall there was in the river; if it didn't come too rapidly, we could get the same in the Fens. Of course if the Fens were properly and thoroughly cleaned out, and the channel built to take the flow of Stony Brook, it would not require anything like the amount of circulation now required in the Fens, and possibly not any.

Q. That is, if Stony Brook were taken out of the way, you mean? A. Yes, if Stony Brook were taken out, or even a portion of it, that is, all of the flow, excepting in very heavy storms.

Q. Supposing you took out the foul flow of Stony Brook, then couldn't you maintain the water at grade 8 and maintain circulation in the basin, provided you allowed a fall of one foot? A. Yes, we could.

Q. One foot rise and fall would be enough, wouldn't it? A. I don't know about that; it would not be enough under present conditions.

Q. No; I mean if you better the conditions with regard to Stony Brook, would one foot rise and fall be enough to keep up circulation in the pond? A. Very likely it would; it could be kept up by pumping.

Q. You mean from the Muddy River channel? A. Yes.

Q. You spoke about the foul flow of Stony Brook, didn't you, and that is the flow that comes during the heavy rain? A. Yes; that is the first flow of a storm.

Q. The first flow of a storm is the worst? A. Yes.

Q. And the rest of it doesn't do much harm, does it? A. The rest of it is not so bad. There never has been any critical examination, that I know of, to find just what the

conditions of Stony Brook are; but we know that the first flow at the beginning of a storm is very bad, and later it is not so bad. It is pretty difficult to say just what the condition is.

Q. What you mean to say is, that the first flow at the beginning of a storm is apt to be pretty foul, and that later it is not so bad? A. Yes; that is right.

Q. What caused these deposits from Stony Brook, if you know? A. Well, I think a good deal of it has come in during the construction of Stony Brook conduit; I have no doubt a considerable portion of the deposit has been caused by that, but there is more or less street wash. There are a good many miles of streets drained by Stony Brook, and it has something like 30 sewer overflows into it. I think the deposit is mostly street wash and sewage.

Q. Wasn't there some special reason for this deposit? A. No; except that the water of Stony Brook comes in there with considerable velocity, and when it gets into the Fens the flow is slower, and the mud settles in the bottom.

Q. Wasn't there some accident in the new work that was done on the Stony Brook? A. I don't know about that.

Q. Tell me this, when was this deposit dredged? A. In 1898.

Q. When that was dredged, it was carried down by hydraulic suction? A. It was pumped out by hydraulic suction and it flowed out into the river, where it settled to the bottom, and then it was dredged and taken away.

Q. It had to be dredged when it got out into the river, notwithstanding that the tide was flowing twice a day? A. Yes, sir.

Q. Do you know anything about the condition of Muddy River, — the river way? A. Yes, sir.

Q. What is the condition of that stream? A. The condition is very good. The only trouble about the river is, that there have been algæ in the water; I don't think it was caused from any surface drainage, because we had it in ponds above when surface drainage comes in.

Q. Are you troubled in what was formerly Muddy River by surface drainage to any extent? A. No, I don't think so.

Q. (by Mr. Dunbar). What is the level of water maintained in your Fens basin? A. The Fens basin?

Q. Yes. A. We maintain it at grade 7; the low-water level was grade 8, but was made grade 7 because we have to have such a large fluctuation of water; allowing it to rise too high would interfere with vegetation.

Q. Could it get into a basin kept at grade 8? A. Yes.

Q. By the way, is there sewage in Muddy River? A. There is only one sewer overflow, as far as I know, and that, I am told, very seldom overflows.

Q. Are you referring now to both sides of the river? A. Both sides; there is one sewer overflow from Brookline sewers.

Q. Is there any house or surface drainage that gets in in any other way? A. I don't know of any other. I don't know of any house drainage; there is a good deal of surface drainage.

Q. (by Mr. MATTHEWS). You say there is no trouble from surface drainage in Muddy River in any way to-day? A. No, there is no trouble from surface drainage. Surface drainage goes in there, but it does not give any trouble, as far as I know.

The following letter, from C. E. Putnam to J. A. Pettigrew, dated Jan. 31, 1901, was put in evidence by Mr. Dunbar, Mr. Putnam stating that a correction should be made in the statement in the letter, that "A large quantity of water from the river will always be necessary to keep the pond from becoming offensive," it being Mr. Putnam's opinion that "it is possible that, with Stony Brook being kept out and the pond thoroughly cleaned, the Fenway Pond could be kept in proper condition, without the admission of water from the river:"—

BOARD OF COMMISSIONERS OF DEPARTMENT OF PARKS,
BOSTON, Jan. 31, 1901.

Mr. J. A. PETTIGREW, *Superintendent.*

DEAR SIR: — A joint Board, consisting of the Board of Metropolitan Park Commissioners and the State Board of Health, in a report issued in 1894, recommended the building of a dam across the Charles River, about 600 feet above Craigie bridge, the dam to be high enough to keep all tide water out of the basin, and to maintain the water in the basin at such a height as might be found desirable. The Board states that: "It is now expected that this height will be the same as that now maintained in the Back Bay Fens, namely, 8 feet above Boston city base (about 2 feet 6 inches below ordinary high tide);" also that there would be but little danger of serious contamination of the water in the river; but if it should become offensive, a sufficient quantity of sea water could be admitted to "keep the basin in a perfectly satisfactory condition, by establishing a very considerable circulation at each tide."

If enough water should be admitted to the basin to cause the water to rise and fall freely between grades 7 and 9, during each tide, no injury would be done to the Fens Pond, as it would still be practicable to maintain the present rise and fall of 18 inches in the pond during each tide. For several years a rise and fall of about 1 foot,

during each tide, was maintained in the pond, by admitting sea water at Brookline Avenue during high tide, and drawing it off at Beacon Street at low tide. This improved the condition of the pond considerably, but did not prevent it from occasionally becoming offensive; and last fall changes were made that increased the rise and fall to 18 inches at each tide. This is the greatest fluctuation that it is practicable to allow, and it is probably considerably greater than would be necessary to keep the river in a satisfactory condition. In order to get this amount of rise and fall, the low-water level of the pond has been lowered to grade 7.

By thoroughly cleaning out the pond, and keeping out of it the dirtiest of the flow from Stony Brook, it could be kept in a satisfactory condition by the admission of a much smaller quantity of water from the river than is now necessary: but a large quantity of water from this source will always be needed to keep the pond from becoming offensive; and it is quite probable that the quantity of sea water necessary to keep the river in a satisfactory condition would be so small that it would not cause the fluctuations in the Fens Pond necessary to keep it from becoming offensive.

Holding the river at a constant level would prevent the admission of water to the pond from that source. The only sources of supply would then be Muddy River and Stony Brook. The supply from these sources would always be unsatisfactory, and during a large portion of the year would be so small that the water in the pond would become stagnant. The large deposit of foul mud in the pond would then produce conditions that could not be tolerated, and for which the surest remedy would be to fill the pond with earth, and extend the Stony Brook conduit to the river.

Respectfully, C. E. PUTNAM,
Assistant Engineer.

Q. (by Mr. MATTHEWS). In this letter you say, "Holding the river at a constant level would prevent the admission of water to the pond from that source." That could be pumped, couldn't it? A. It could be pumped; yes, sir.

Q. And it could be allowed to fluctuate 1 foot? A. Of course that would not be holding it at a constant level.

Q. Then what do you mean by holding it at a constant level? A. Allowing no fluctuation whatsoever.

Q. And it was a dam which was to hold this water at grade 8 without any fluctuation at all that you had in mind when you wrote this? A. That was so stated in the report of the joint Board.

Q. That is, what you thought the proposition was when you wrote this report was to hold the water at a constant level, — never varying; is that right? A. That was the question I was answering.

William M. Brown, engineer of sewerage works, Metropolitan Water and Sewerage Board, was called, and the following letters were put in evidence: —

COMMITTEE ON CHARLES RIVER DAM,
BOSTON, Jan. 21, 1902.

HENRY H. SPRAGUE, Esq., *Chairman, Metropolitan Water and Sewerage Board, Ashburton Place, Boston, Mass.*

DEAR SIR: — In the report which you made to us January 7, you stated that, with a dam holding the Charles River permanently at an elevation of 8 feet above mean low water, it would be necessary after each shut-off on account of storms to pump out the water stored in the city sewers below grade 8. Will you kindly let us know how serious a matter this is, and what the expense of the pumping would be?

In the same communication you also suggested that, under the same state of affairs, there would be increased leakage into the sewerage systems. Can you let us know about how much leakage now exists and about how much you anticipate the increase would be, and how serious a matter that is?

We would also like your opinion on the following: That, if a dam was erected, say where the present Craigie Street bridge now is, and the same conditions existed regarding storm overflow on the north side of the river as now exist, and on the south side of the river as would probably exist after the high-level sewer system is completed and in operation, whether the amount of sewage that will come into that basin is more than is safe for the health and comfort of the persons living around that basin, assuming that the basin is kept as a fresh-water basin, and at grade 8?

Will you also state whether it is possible to increase the amount of storm water taken care of by the north metropolitan system above the dam at Craigie Street, and especially in the months of June, July, August, September and October?

Will you please state the maximum capacity of the metropolitan sewer at the Charlestown pumping station, which, as we understand, is the pumping station taking care of the Cambridge district.

There is to be a hearing before this committee on Wednesday, January 29, at 10 A.M., at Room 203, Congregational House, at which hearing we expect to have a statement from the Boston Park Commission in reference to the drainage of the Fens, and from the State Board of Health and the town engineer of Watertown. We should be glad if a representative from your office could be present at this hearing, and explain to the committee and the counsel any facts connected with the questions we have addressed to you.

Very truly yours, J. W. LUND,
Secretary.

METROPOLITAN WATER AND SEWERAGE BOARD,
BOSTON, Jan. 28, 1902.

HENRY S. PRITCHETT, Esq., *Chairman of Committee on Charles River Dam, Room 203, 14 Beacon Street, Boston, Mass.*

DEAR SIR: — The letter of your committee, dated January 21, addressed to Henry H. Sprague, chairman of this Board, has been handed to me for reply.

The expense of pumping water stored after storms in Cambridge sewers below elevation 8 is estimated at $450 per annum.

The infiltration of ground water into Cambridge sewers may be approximately estimated as the difference between the dry weather flow of sewage and the normal water supply of the city, — about

2,000,000 gallons per day. Additional leakage into sewers, due to the construction of proposed dam holding the water level of the Charles River at elevation 8, may amount to 1,000,000 gallons per day, the cost of pumping which is estimated at $400 per annum.

It may be assumed that the additional pumpage of stored water and leakage into sewers on the south side of the Charles River would approximate that on the Cambridge side after the completion of the high-level sewer.

Concerning the degree of pollution by storm overflow discharge into the proposed basin, authorities are generally agreed that where sewage is discharged into a running stream there should be a flow in the stream of not less than 2½ cubic feet per second to each 1,000 persons contributing sewage. Under unfavorable conditions, it is held that this rate may need to be increased to as much as 7 cubic feet per second for the same number of persons. The above rates give dilutions varying from 16 to 1 to 45 to 1. Applying to these ratios the 7 per cent. of sewage discharge recorded as now passing into the river by storm overflows, we have, for the mean daily flow of 220,000,000 gallons in the Charles River, a dilution of 160 to 1. Taking the ordinary summer flow of the river, of 40,000,000 gallons per day, the rate of dilution is reduced to 30 to 1. This shows a considerable margin over the dilution necessary for a running stream similar to the Charles River; so that, even in its impounded condition, the sewage thus admitted could hardly be a source of offence at the present time, if delivered at points favorable for the removal of deposit by the contemplated measures for changing the body of water in the basin. There is a further favorable consideration in the tendency in sewer design, on both sides of the river, towards the abandonment of the combined and the substitution of the separate system. It would doubtless be found desirable to expedite, as far as practicable, the change now being gradually effected in this respect, so that at no very distant date the greater part of the domestic and manufacturing wastes now entering the river by storm overflows may be carried to the pumping stations of the sewerage works, after which time the only pollution reaching the river would be the first wash of streets due to storms. As this is but a very small proportion of the total rainfall, it could be collected in interceptors of moderate dimensions, discharging below the dam, whenever found desirable, leaving the greater part of the storm water to permanently pass into the basin.

Meanwhile, it is possible to increase the amount of storm water now taken care of by the north metropolitan system above the proposed dam. The capacity of the metropolitan sewer, where it leaves Cambridge, is about 40,000,000 gallons per day; and the regulating valves, as at present adjusted, cause the city sewers to overflow when the metropolitan sewer is carrying 27,000,000 gallons. The remaining capacity could be made available for additional rainfall by changing the adjustment of the regulating valves. The maximum capacity of the metropolitan sewer at the Charlestown pumping station is about 68,000,000 gallons per day, and the maximum pumpage at the station during the past year has been about 51,000,000 gallons per day.

Yours respectfully, W. M. Brown,
Engineer Sewerage Works.

Q. (by Mr. Matthews). I would like to ask you the same question which I asked another witness this morning,

not relating to the subject matter of your report. Is there any overflow that now gets into the river above Watertown dam? A. The local systems occasionally overflow in times of high storms. The Charles River interceptor backs up in times of storm. They have overflowed in Newton, and I think occasionally in Waltham, — rarely, though; there have been no serious results from them.

Q. Nothing that has been considered injurious to health? A. I should think not.

Q. Have you any records from which you could calculate the overflow of the Watertown dam? A. I have not. The commission which considered this dam project a year or so ago presented data on the flow of the river, and those figures in my report were abstracted from my report.

Q. Were they predicated on the method adopted on Sudbury River records? A. The Sudbury method was substantially followed.

Q. Then your figures were not based upon the Watertown dam? A. No.

Q. In this letter of yours that you have just read you have said that dilution of the basin furnishes a large margin of safety. Is that opinion predicated on the flow of the stream alone, or is it predicated on the flow of the stream plus the capacity of the basin? A. It is based on the flow of the stream, and the supposition that a dam would be created there which would control the flow of the river, and that this would be constructed somewhere near the line that would control the wash-outs, or whatever openings were made in the dam.

Q. Your opinion is predicated upon the operation of this dam so as to include the fresh water basin behind it? A. No special consideration given to it. I think that the water, properly handled, whether fresh or salt, would be sufficient to break it up.

Q. Then you have no objection to the admission of some salt water in this basin? A. I don't see any objection to it.

Q. You said something about 7 per cent. of sewage in your answer to the chairman; what was that figure? A. Some records have been maintained by the city of Cambridge in recent years in which the overflows from city sewers have been approximated. The overflow ranges, as I recall it, from 4 to 8 per cent., and I assumed that 7 per cent. might be a reasonable allowance for a consideration of this kind. It might be larger, but I should say that 7 per cent. of overflow was an extreme proposition to apply to a basin of this kind.

Q. That is not a figure which you find in Mr. Hastings' work, but it is a figure which you adopt as being, beyond all possibility, a safe figure? A. I should say that it was a safe figure. I think his later observations are somewhat lower.

Q. Is it the proper process, Mr. Brown, when the reduction has been caused by some specific operation in the sewerage system, as he stated was the case, as in the operation of the pumping system — A. I doubt if that is the fact.

Q. You doubt if that is the fact? A. Yes, sir.

Q. So that you think it was better to take the three years? A. Yes.

Q. His figures give hours, and not percentages, don't they? A. Yes, and we reduced that to the yearly overflow, — into percentages.

Q. Would you mind communicating that to the commission? A. Mr. Hastings telephoned to me the figures. It is on file in my office. If you desire it, I will file it.

Mr. MATTHEWS. If you will do so, I would like the exact step which you adopted in making your calculations.

In reply thereto, Mr. Brown sent the committee the following letter: —

METROPOLITAN WATER AND SEWERAGE BOARD,
BOSTON, Jan. 29, 1902.

JOSEPH W. LUND, Esq., *Secretary, Committee on Charles River Dam, Room 203, Congregational Building, 14 Beacon Street, Boston.*

DEAR SIR: — At a hearing in Room 203, Congregational Building, to-day, on the proposed Charles River dam, Nathan Matthews, Jr., attorney, requested that a statement be filed with the committee showing the method by which an estimate of 7 per cent. was arrived at as the period during which the sewers of Cambridge are shut off from the metropolitan sewer, and, in consequence, overflow into the Charles River.

Records in the office of the city engineer of Cambridge show that the Binney Street regulator, which is taken as characteristic of others, was closed as follows: during the year 1899, for 600 hours; 1900, 655 hours; 1901, 490 hours; an average of 582 hours per annum, which, for convenience of calculation, has been taken as 600 hours. This is equal to 7 per cent. of the 8,760 hours in one year.

Yours respectfully, WM. M. BROWN,
Engineer Sewerage Works.

Q. (by Mr. DUNBAR). What did you mean, Mr. Brown, by this, in your report: "The sewage thus admitted could hardly be a source of offence at the present time, if delivered at points favorable for the removal of deposit by the contemplated measures for changing the body of water in

the basin." A. In the design presented by the joint Board there were discharge channels, a large tidal lock, and other methods of changing the water in the basin. If the sewage was discharged somewhere near those channels it would be washed out into tide-water below the dam.

Q. Where were those plans? A. They were submitted with the joint report, some years ago.

Q. In 1894, do you mean? A. I do not remember the date, but it was the joint Board of Health and Parks report.

Q. Yes. I think that was the one. Then your opinion here would depend upon the delivery of this pollution above points where the plans there of which you spoke indicate it should be delivered and carried out directly? A. Those or any others which might be of that character somewhere near the range of influence of the currents in the basin above the dam.

Q. What do you mean by "within the range of influence?" Near the bridge? A. No; near any currents in the basin above the dam.

Q. Would it go back so far as the overflow of Stony Brook up at the Fens? A. It might have an influence at that limit; it would depend somewhat on the size of the outlet of the channels.

Q. Would it go back so far as this point above at Essex Street? A. If it was large enough, it would go back.

Q. What you contemplated? A. I did not contemplate anything. I said if it was placed within the range of influence of this, it would control a certain area.

Q. If the dam were placed substantially at grade 8, with a fluctuation of only a foot, would you say that Stony Brook overflow or Essex Street overflow would be within the plan which you contemplated? A. You are getting down to specific limits, and I should not care to give specific opinions. I have been asked for a general opinion, and I have given that, but before I should care to give a specific opinion, I should have to have time to make a special study of the subject.

Q. You understand that when this plan is carried out it must be carried out specifically? A. I understand so, and at that point I should say that if anybody presented to me a specific plan I should give my judgment so that it could be the result of special study. I should say if it was within the limit, any discharge would draw the deposit to the tidal wave.

Q. There is one thing here not very clear, Mr. Brown: "Applying to these ratios, the 7 per cent. of sewage dis-

charge recorded as now passing into the river by storm overflows," you say, "we have, for the mean daily flow of 220,000,000 gallons in the Charles River, a dilution of 160 to 1." Above this you say: "Concerning the degree of pollution by storm overflow discharge into the proposed basin, authorities are generally agreed that where sewage is discharged into a running stream there should be a flow in the stream of not less than 2½ cubic feet per second to each 1,000 persons contributing sewage. Under unfavorable conditions it is held that this rate may need to be increased to as much as 7 cubic feet per second for the same number of persons. The above rates give dilutions varying from 16 to 1 to 45 to 1. Applying to these ratios the 7 per cent. of sewage discharge recorded as now passing into the river by storm overflows, we have, for the mean daily flow of 220,000,000 gallons in the Charles River, a dilution of 160 to 1. Taking the ordinary summer flow of the river, or 40,000,000 gallons per day, the rate of dilution is reduced to 30 to 1." Do you mean by that that only 7 per cent. of the sewage discharged now by Cambridge passes into the storm overflow? A. That is my opinion; yes, sir.

Q. You mean that 7 per cent. of it does pass into the river? A. I assume something like that.

Q. That is, one-fourteenth of the whole sewage of Cambridge gets into the river; is that it? A. That is approximately the ratio; yes.

Q. (by Mr. BAILEY). That is, at times of overflow, isn't it? A. Yes, sir.

Q. (by Mr. DUNBAR). That is the same on the south side, isn't it? A. I should say so, approximately. I mean to say that would be the condition after the system is complete. I think the overflow there at present is greater than that.

Q. There is another question that has been suggested to me, Mr. Brown. Suppose your basin is kept at a permanent level, or substantially permanent level, what would be the effect on the ground water? A. I think the present level is now about grade 8. I think it would raise the ground water somewhat.

Q. Have you any evidence of it? A. No, sir; I have not.

Q. The average grade now, you say, is about grade 8? A. Substantially grade 8; yes, sir.

Q. And what is the average tide level? A. The average high tide almost grade 10.

Q. And the average low tide? A. Grade 0.

Q. Or the average mean tide? A. About grade 5.

Q. Would the increase in the level of the ground water be proportional to the increase of the level of the water in the basin? A. I could not say. I have no data about it.

Q. Have you any opinion about it? A. My opinion is that it would be higher than the present grade 8.

Q. Are there any data upon that question, that you know of? A. Nothing that occurs to me now; there is nothing that I recall.

Q. (by Mr. Matthews). Just one question. You said, in reply to Judge Dunbar, that you thought the maximum amount of sewage discharged into the river was 7 per cent. That meant, I believe, during the time of overflow? A. For 7 per cent. of all the time of the year, the sewers are overflowing from Cambridge.

Q. That is, 7 per cent. of the total amount of sewage is the overflowing sewage? A. The total of sewage overflow is 7 per cent. from Cambridge. There is some small part of it gets into the metropolitan sewer; there are a few separate areas that drain on the metropolitan system, and a few manufacturing establishments that drain into it.

Q. Of the total amount of the Cambridge sewage, throughout the year, 365 days, there is a given number of gallons, and of that you say 7 per cent. gets into the river? A. I should say 7 per cent. of all the deliveries of sewage into the sewers in the city of Cambridge is delivered into the Charles River.

Q. (by Mr. Abbott). That includes, does it not, the combined flow of both sewage and storm waters into the sewers? A. It includes the storm water flow, but the sewage at the time goes with it.

Q. And in your computation or estimate of 7 per cent. do you separate in that the storm water from sewage, and reckon that 7 per cent. of sewage undiluted with storm water finds its way into the Charles River? A. I do; yes.

Q. How do you arrive at that estimate? A. If the sewers of the city of Cambridge are delivering all the time into the river, and not anywhere else, the sewage of that city must go with it.

Q. And do you base that upon the records of the engineer of the city of Cambridge, or on your own records? A. I base it on the records of the engineer of the city of Cambridge; that may be a wrong record, but it is the only record that I know of.

Q. And those data show, do they not, that the time when the tide gates are closed is a longer period than when the

regulators indicate that the water is not flowing into the metropolitan sewer? A. Partly; yes, sir.

Q. Pardon me; that the regulators are closed for a longer time than the tide gates are opened? A. No.

Commissioner DANA. The tide gates are open.

Mr. ABBOTT. Yes, that is true.

Q. So the discharge takes place when it is very much diluted by storm water. A. I think that is an extreme proposition, and ought to be considered at this time.

Q. (by Mr. PILLSBURY). The statement amounts to this, does it not, that, in the present state of things, 7 per cent., being about one-fourteenth of the sewage of Cambridge, is being carried into the Charles River? A. That is my judgment. I said I thought it was an extreme statement, and that in a study of this kind it ought to be considered.

Q. (by Mr. MATTHEWS). And then upon that figure you reached the conclusion that there is a large margin of safety? A. There is a large margin of safety, if this is delivered properly in channels, discharge channels, which might be created in connection with this dam.

Q. (by Mr. ABBOTT). Don't the observations that have been made in Cambridge show that there has been a diminished discharge of sewage at times of storm overflow during the past year from previous years? A. My recollection of the statements made to me by the engineer of Cambridge was that last year it was somewhat in the ratio of 5 to 7 of his extreme record. It was reduced somewhat.

Q. (by Mr. BAILEY). So that that percentage would be greatly reduced? A. Well, I think that is an open question. It might, or might not.

Q. (by Commissioner DANA). Isn't it true that during the time shown you did actually pump more water in Cambridge? A. We pumped 3,000,000 gallons more, I think. I think the increase was about 10 per cent.

Q. Then, if I understand it, it would be still further reduced by increasing the pumping capacity? A. The capacity is 13,000,000 or 14,000,000 gallons through the sewer in the city of Cambridge, and that could be entirely used for pumping.

Q. Then, if the dam was put there, you could so regulate the pump that it would still further reduce that? A. That would reduce the period of overflow; yes.

Q. (by Mr. MATTHEWS). Do you include in those calculations the Binney Street outlet? A. Yes.

Q. Let me ask you if you have any means of ascertaining the amount of relief that will be afforded to the Boston main

drainage system to accommodate the increased quantity of surface drainage when the high-level sewer is finished? A. The capacity of our sewer entering the Boston main drainage works is about 65,000,000 gallons a day, and we are delivering there about 17,000,000 gallons a day; so that the average daily delivery would be reduced, I think, 15,000,000 gallons, and in storm conditions the 50,000,000 or 60,000,000 gallons could be delivered to the main drainage system.

Q. And that would be reduced for one purpose and made available for another? A. Yes.

Q. And it would enable the city to take a larger portion of overflow from the Back Bay district down to Moon Island? A. Yes, it would; they could use it to the extent that we are not using it.

Q. It would be a relief to that extent? A. Yes, it would be a large relief for the Back Bay district, if properly applied.*

Q. (by Mr. BAILEY). What I gather from what you say is, that, taking your experience from what you know of the situation, you believe that 7 per cent. of the Cambridge sewage empties into the Charles River? A. Yes, I think that 7 per cent. of the Cambridge sewage empties into the river.

Q. Yes. That was my purpose in asking you, to get that right. A. Yes.

Mr. Wilbur F. Learned, town engineer of the town of Watertown, then read his report to the committee, as follows: —

WATERTOWN, MASS., Jan. 17, 1902.

HENRY S. PRITCHETT, Esq., *Chairman Committee on Charles River Dam.*

DEAR SIR: — Watertown has a frontage on Charles River below the dam of 3.5 miles, which, with the exception of the arsenal grounds on the north side and 1,500 feet in length on the south side, has been acquired by the Metropolitan Park Commission. The metropolitan sewer is built on the south bank of the river for a length of 500 feet, and for the remaining length of 3,300 feet the sewer is built in streets generally parallel with and near the river, at grade 7.60 at the lower end and 9.20 at the upper end, with no overflow intervening.

The town has a separate system of sewerage, divided into three districts: The south district with an area of 110 acres, has an aggregate length of 2.74 miles of sewers; the main, or central district, has an area of 1,000 acres and a total length of 15 miles of sewers; and the east district, comprising an area of 500 acres, has a total length of 12 miles of sewers. The whole system is connected with the south metropolitan sewer. The south system has two connections, one on

* In connection with this question see letter of G. C. Emerson, on page 131 of this report.

Water Street and the other on Watertown Street, where an overflow at grade 14 connects with Porter's tail-race. The central system connects by a syphon at Galen Street bridge, where an overflow at grade 14 is located; and the east system discharges into the metropolitan system through a syphon located at the easterly end of the arsenal grounds, opposite the Brighton abattoir. The overflow is placed at grade 8.70, and in all cases they are used only in cases of emergency, which has not yet occurred. No sewerage from the town is now discharged into the river.

A drainage system has been built for an area of 31 acres, situated in Watertown on the south side of the river, the outlet of which, at the foot of Water Street, is set at grade 10.72. The central and east districts, having no regular system of drainage, discharge their surface water into the brook flowing into Charles River.

The town contemplates building in the near future a drainage system for a water-shed of 658 acres, situated in the central part of the town, with an out-fall near Beacon Square, set at grade 10. No public work is in contemplation that will interfere with the proposed full basin in Charles River.

Yours respectfully, WILBUR F. LEARNED,
Town Engineer.

Q. (by Mr. MATTHEWS). What do you mean by drainage district? A. That is the water-shed of any district.

EDGAR S. DORR, chief engineer of the sewer division of the city of Boston, called.

Q. (by Mr. BAILEY). You have heard the question that has been asked several times by Judge Dunbar relating to a deposit in the Fens. Do you know about that deposit, and, if so, will you tell us how that came there, and the nature of it? First, where was it, — let us identify it first. A. At the outlet of the commissioners' channel in the Fens Pond.

Q. (by Mr. BAILEY). Now, will you tell us how that happened? A. On two separate occasions, by accident, the whole volume of the Stony Brook valley sewer was discharged into the Stony Brook conduit; once in 1897 for a period of a couple of months, as near as I can recollect, and again in 1900 for a shorter period. The main sewer was broken, through the operations of contractors who were building Stony Brook channel right alongside of it, and the whole flow went down into it, and of course was conveyed immediately to the Fens Pond.

Q. And the result of it was to cause that deposit? A. I think it was principally responsible for that deposit.

Q. (by Commissioner DANA). Has there been any trouble since 1900 by any of the sewage getting into that Fenway? A. I think not.

Q. (by Mr. DUNBAR). Is the water rather shallow at that

stone bridge there a little further down? A. I am not positive as to the depth of water in the Fens Pond; the matter does not come under my authority.

Q. What observations have you made at the Fens Pond and the discharge into them personally; what do you know about it, in other words, from your personal observation? A. I have made no particular observations, — not lately; at the time of these overflows I did.

Q. At the time you were last here you did not know anything about this shoaling up there, or the causes of it? A. I don't think I was asked about the cause of it; I knew about the shoaling, and testified about it at great length.

Q. You were asked to tell us about the Fens. A. I don't remember exactly what my testimony was, but I think the questions were as to depth of water, and I referred to the Fens engineers.

Q. The other day, when you were asked about this, did you know about the cause of the shoaling, — what the cause of the shoaling was? A. Yes.

Q. Where did you get your knowledge? A. From my experience in the division. I knew of the fact of the overflow, but I did not testify to it because I was not asked, — that is about these breakdowns, — these accidental causes.

Q. If you made no observation as to the shoaling, how did you know to what the shoaling is to be attributed? A. Well, I cannot say that I actually traced the material from the sewer to the Fens; but, knowing the material was going there, our department practically admitted it was due to our operations, and bore the expense.

Q. Isn't there other material going there at other times? A. There is other material, of course, from street wash.

Q. From personal observation, you don't know when the material came down there? A. Yes, sir; I was convinced that some of it was sewage sludge, and my common sense told me where it came from, because I knew about the breaking down of the sewer.

Q. (by Commissioner Dana). This map, dated Jan. 6, 1902, which is from the street department, shows all outlets along Stony Brook channel for storm overflows? A. Yes, sir.

Q. And those are indicated how? A. In the manner you see, with conventional signs, — red semicircle; we have indicated them. There it is rather faint.

Q. That shows on both sides of Stony Brook? A. On both sides of Stony Brook; yes.

Q. Is it the plan of the department to intercept those? A. Partly.

Q. At the beginning of storms? A. The plan of the department is to develop a complete separate system throughout the valley by taking the surface water out of the common sewers.

Q. The system that was spoken of for diverting the worst overflow at the beginning of storms through the new conduit, — how is that to be connected with the whole system? A. By the channel that I spoke of carrying the foul flow, — that is, designed to take the first flow and divert it directly to the river without going to the pond.

Q. That is to be connected with the mouth of Stony Brook, is it, as it comes into the Fens? How is that to be operated? A. It will have to be operated by some form of gate chamber in the large channel.

Q. (by Mr. MATTHEWS). Right under Stony Brook, Muddy River, what is that? A. On Muddy River there are no overflow outlets on the Boston side; there is one on the Brookline side, and I see the draughtsman has indicated it in rather faint coloring, perhaps because he was not sure just where the outlet was.

Q. You understand there is only one overflow into Muddy River? A. I know there is only one on the Brookline side; from the Boston side there is no overflow.

WILBUR F. LEARNED — *recalled.*

Q. (by Mr. MATTHEWS). Are there any records that you know of in regard to Watertown dam? A. No records, but there was a report made by Mr. N. Henry Crafts, formerly engineer of Boston, where he goes into the matter of the maximum and minimum flow of Charles River at length. That report was made in 1878.

[Report of N. Henry Crafts, civil engineer, to town of Watertown, on drainage and sewage, April, 1878, sent to the committee by Mr. Learned.]

Q. Do I understand that there are no records of the flow over the dam? A. Not that I know of.

Q. Hasn't something been done in that regard? A. It is barely possible that there may have been records taken at Waltham dam at Moody Street, but none in Watertown, to my knowledge.

Q. You haven't any in your possession? A. No.

Q. (by Mr. DUNBAR). Wouldn't the volume of water coming down the river now be different from what it was in 1875? A. I presume it has increased some on account of the development of the Charles River valley. As the water-

shed becomes developed we will get water in a quicker time over the dam in the future than we have in the past.

Q. You won't get more water, would you? A. Probably not.

Q. Would the fact that Newton, Brookline and Hyde Park and those places have their water supplied from Charles River affect the volume of the flow of the river? A. I should not think it would, materially. They do not pump directly; they pump indirectly.

Q. Do you know anything about that, or is it simply a guess? A. That is simply my judgment.

Q. Would there be any sense, then, in the Legislature restricting the amount of water which each of those cities shall take, if it is not going to affect the volume of water in the river? A. There would be, if they pumped direct.

Q. You know the Legislature has restricted the amount of water they should take? A. No, I did not know that.

Q. That is the fact. Now, if that is the fact, what is the reason for it? A. They probably thought it diminished the flow of water in the river.

Q. Do you suppose they acted on accurate knowledge? A. I should suppose so.

Q. Then, if they had accurate knowledge, it is to be presumed that it diminishes the flow? A. That is possible; that is common sense.

Q. Is there any way of getting at the flow now, showing the increase or decrease since 1875? A. I think not.

Hearing adjourned.

The following letter from G. C. Emerson to Nathan Matthews, Jr., in reference to the relief which the high-level sewer would afford to the Boston main drainage system, was presented to the committee: —

BOSTON, March 11, 1902.

Hon. NATHAN MATTHEWS, Jr.

DEAR SIR: — In answer to your recent verbal request, I submit for your consideration a few facts relating to the effect which the completion of the various sewerage works now in process of construction by the Commonwealth and the city of Boston will have upon the flow of sewage into the Charles River basin. These facts have been nearly all considered at different times during the hearings before the Charles River dam committee, but have not been considered collectively, and have not, I think, been given such prominence as their importance warrants. The principal of these works are: —

The metropolitan high-level sewer, which will divert a large proportion of the present flow in the city of Boston system to a new outlet.

The building of the new 75,000,000 gallon pumping engine now in process of construction for the Cow Pasture station.

The extension of the closed channel for the waters of Stony Brook,

with its accompanying low-level sewer for the territory in West Roxbury.

Considering these works in the above order, the metropolitan high-level sewer will divert from the city of Boston system the sewage of approximately 21 square miles of Boston territory out of a total of 34 square miles now tributary to this system, and, in addition to this area, the various areas in Brookline, Newton, Watertown and Waltham which are now tributary to the Charles River metropolitan system.

According to the report of the Metropolitan Sewerage Commissioners for 1899 upon a high-level gravity sewer, the population of this diverted territory (using figures for the year 1900) is 195,500, or 43 per cent. of the entire population tributary to the city system at that time. The diverting of the Charles River system alone, which is built practically on the separate system, will, it may properly be assumed, prevent all overflow into the Charles River for which this system is now responsible. That the Charles River system is responsible in a large measure for the present crowding of the city system is shown by the large number of complaints to the street department from districts from which few, if any, complaints were received previous to the connecting of the Charles River system with the city of Boston system.

The diverting of the sewage of the Dorchester and West Roxbury districts will greatly relieve the Boston intercepting sewer, and therefore allow a much greater portion of the sewage of the city proper to reach the pumping station than at present.

Again, quoting from the Sewerage Commission report, page 51, it is stated that the estimated maximum flow, and therefore the probable flow, to the Cow Pasture station will be, for the year 1900, 86,000,-000 gallons approximately, and for the year 1935, 155,000,000 per day, including storm. (I am unable to state if this calculation includes the flow from exceptionally heavy showers or not.)

The installation of the new pumping engine at the Cow Pasture station will increase the theoretical pumping capacity of the plant about 56 per cent., but, as it is found to be practically impossible to keep all pumps of the present plant working at the same time, the actual increase will be about 68 per cent.

The Dorchester Bay tunnel beyond the pumping station is not, however, of sufficient capacity to deliver the entire pumpage of the completed plant, and the increase in efficiency will be limited by the capacity of this tunnel, which is about 154,000,000 gallons per day, or about the same amount as the Sewerage Commission calculate to be the maximum flow in the year 1935. The reserve in pumping capacity will, however, enable maximum efficiency to be maintained at all times.

According to these figures, therefore, it seems that there should be no overflow into the Charles River until the year 1935, except in case of injury to the pumping plant or possibly during an exceptionally severe storm.

Lastly, I would call attention to the building of the West Roxbury low-level sewer in connection with the Stony Brook improvement. This sewer will take the sewage of a large area of low-level territory, much of which at present finds its way directly into Stony Brook.

Yours respectfully, GUY C. EMERSON.

N. B. — The figures showing the area of 21 square miles of Boston territory which will be diverted from the city of Boston main drainage system by the metropolitan high-level sewer were obtained from the plans prepared by the sewer division of the street department of the city of Boston, a copy of which is herewith submitted.

SIXTH HEARING.

OFFICE OF RAILROAD COMMISSIONERS, 20 BEACON STREET,
BOSTON, Feb. 27, 1902.

The hearing was begun at 10.20 A.M., Chairman Pritchett presiding.

The CHAIRMAN. The committee at its last sitting completed the hearing so far as regards reports by official branches of the city government and of the corporations which are adjacent to the city of Boston, and it was understood that this morning we were to begin with the consideration of a general statement and plan put forward by those who think a dam desirable and feasible across the Charles River; and I shall ask Mr. Storrow to proceed with whatever statement he desires, and to call such persons as he desires to call to make statements in connection with this plan.

Mr. ROBERT F. RAYMOND. Mr. Chairman, I appear as counsel for the Massachusetts Civic League, which is interested in such matters of public interest. I have nothing to say about the feasibility of the project at the present time, but I want to say, in respect to the desirability of this matter, that the Civic League would like to see such a dam built. In certain of the crowded wards of the city, such as wards 6, 7, 8 and 9, certain people in those wards were asked to take up and consider this matter and to give the league the benefit of their ideas on the subject; and without urging especially on the part of the league we have had petitions signed which I would like now to present to the committee. These petitions come from the South, North and West Ends, and from the crowded districts of the city, and are in the following words: —

We, the undersigned, residents of wards 6, 8 and 9, of the city of Boston, respectfully urge on the committee appointed by the Governor, under the provisions of chapter 105 of the Resolves of 1901, the desirability of constructing and maintaining a dam across Charles River between Boston and Cambridge, in the vicinity of the bridges known as Craigie bridge and West Boston bridge. We believe that our city should avail itself of the opportunity of making a water park of the lower Charles River basin; and we believe that such a water park would not only beautify Boston, but would offer valuable opportunity for out-door play and recreation to residents of all sections of the city.

Signed by David Wyzanski and 500 others.

The CHAIRMAN. Those will be placed on file. I take it that you present those as some of the indications as to the desirability of the project. Now, will you proceed, Mr. Storrow?

Mr. STORROW. President Eliot of Harvard University has been kind enough to come here to say a few words this morning on the general subject of the desirability of placing a dam across Charles River and making a water park as proposed.

President CHARLES W. ELIOT. Mr. Chairman and gentlemen, I was very glad to hear the petitions which have just been placed on file, because my own feeling about this proposed improvement in the Charles River basin and along the river is that it is one in the interest of the people by the hundred thousand, and that many of the representations that have been made before your committee and before committees in earlier years have really proceeded from comparatively small groups of persons and from comparatively insignificant interests. This project goes back now at least thirty years, — I mean the project of a dam across the Charles River and the conversion of the basin of the river into a 7 mile long water park has been urged and has been resisted under a variety of grounds. To my thinking, the principal ground has been put forward very seldom. The principal ground seems to me to be the health and the happiness of the 400,000 people who live within an easy walk of this 7 mile long park, which nature has really provided, but who are almost dumb, — this great multitude, whose health and happiness and well-being are really the ultimate business for which we ought all to live and strive. This great multitude, — it is difficult for us to represent to ourselves the condition in which they are; it would require a good deal of imagination. I hope the members of this committee have that valuable faculty of imagination in large measure; I am sure they need it. It is the chief faculty which leads men towards improvement, whether in science or in art or in public sanitation, and health-giving and happiness particularly. We have to imagine the presence of beauty which can be brought out of the Charles River and its basin. We have some attempts now going back at least thirty years to represent in pictorial form that beauty, but for the most part we have to imagine, and the vivid imagination of a landscape architect sees it all clearly from Craigie bridge away up to the dam in Watertown. That is a picture which ought to have a great influence on this subject, and the consideration of the precise question whether

the dam ought to be built or not. The dam is essential to the production of the greatest beauty, as it is, I suppose, essential to the reaping of the profit from the basin and the banks of the Charles River which the neighboring cities are entitled to reap. It is also necessary to the sanitation of the valley of the river below Watertown, with all its extensive low lands and marshes.

But what I want to dwell upon, in the very few minutes that I can claim the attention of the committee, is that the fundamental thing that we are seeking here is the health and happiness of a great population. As I consider the membership of this committee, knowing something of their habits of life in winter and summer, I feel an apprehension that no member of this committee may have seen the immense contribution to the public well-being which has been wrought out at Revere beach. Has any member of this committee seen 70,000 people on that beach of a summer evening? Has any member of this committee seen the immense enjoyment and the health-giving which takes place at City Point and at Castle Island during three months or four months of every year? I cannot help wondering if any member of this committee has visited the North End Park and the beach below Copp's Hill, and seen the hundreds and even thousands there who were enjoying that small opportunity for seeing the water and of enjoying themselves there, — a small park in the midst of thousands of people whose opportunities of enjoyment are very limited in this world. I wonder if any member of the committee has walked of a June or of an October evening on the Charlesbank, — the provision made by the city of Boston, — an admirable provision, — made here for a population crowded, airless, living all together in narrow space. The sight of the people gathered on the Charlesbank on any fair evening between the first of May and the first of November would go far to convince any person who really believes that cities exist and that commonwealths exist to promote the well-being of the people, that this great improvement of the Charles River basin and of the banks of the Charles River is a thing fit to be done by this intelligent Commonwealth. If none of the gentlemen have seen those things, I wish the more heartily that your imagination may be strong enough to present them all to you. These are great arguments for this public improvement. I recognize absolutely the force of all the considerations which relate to the preservation of Boston harbor. They seem to me to be well determined, and I am sure that the committee has had

the advice of competent experts on that subject, and I realize the force of the argument and the profit which the municipalities may reap by rendering the present low lands and marshes occupiable by human kind. But these considerations, after all, seem to me to belong in a second rank; because the great modern communities do not exist ultimately and in the end for commerce, but commerce exists for them; nor do municipalities exist for profits in money, but municipalities exist for the people who live in them, and the supreme object is the well-being and happiness of the community.

Mr. STORROW. The Very Rev. William Byrne, Vicar-General of the Archdiocese of Boston, who resides in the West End, has been kind enough to say he would speak to the committee on this subject. He is here, and I ask him to say a few words.

Very Rev. WILLIAM BYRNE, V. G. Mr. Chairman and gentlemen of the committee, as a present resident of ward 8 and a prospective resident of the Back Bay district, I am particularly and doubly interested in this proposed improvement, and I think that it may be summed up in one sentence,— all that I need to say on the subject, because others no doubt will present to you arguments why this improvement should be made; and I assure you, as President Eliot has already done, the sanitary reasons and the reasons of beauty each demand that this improvement should be made. Unless I might appear to be slighting the subject, I will just say one word or two in that direction. Nature usually endows her provisions with beauty; but nature, like Homer, sometimes nods, and, like fallible man, she sometimes makes mistakes. The banks of rivers as they flow through the country and before they approach the sea are generally sufficiently beautiful,—at least they are not offensive to the eye; but when they are about to discharge themselves into the ocean they often pass through squalid marshes and low lands, where they are affected by the ebb and the flow of the tide; and they are liable to expose at times great mud flats, which are not only unsightly but unsanitary and dangerous to the public health; and when these mud flats are the products, as they often are, of the filth and the discharge of silt and sewage of a great city, they become not only exceedingly offensive and unsightly to the eye, but to all the senses, and dangerous and injurious to the public health.

Now, that is precisely the condition of that part of the Charles River which you propose to improve and to beautify and make more sane; and, although I am entirely free to

say that I am no expert on the matter of sanitation or engineering, from a little thought that I have given and from the opinions of others whom I have consulted or who have spoken to me on the subject and whose opinions I very much respect, I am quite certain that some means can be found for obviating any objections which may be brought against this improvement from sanitary considerations. I have so much respect for the skill of modern sanitary engineering that I am quite sure they can find a remedy for all the trouble of that kind. Now, whether this project of flushing the river so as to produce a water park by means of a dam is the best plan, I would not say. It seems to me to be the cheapest plan, and, as for any of the disadvantages which might arise from it, I should say that they are so small that they could easily be obviated, and I would hardly think they were great enough to counterbalance the great advantages which would result. A great deal has been done to beautify the banks of the Charles River, both on the Boston side of the river and on the Cambridge side of the river, — I think more on the Cambridge side of the river than on the Boston side; but I think you will all agree that a great deal more remains to be done in order to make it a "thing of beauty and a joy forever," and a permanent improvement that would be satisfactory and advantageous to the whole community. I certainly am heartily in favor of some plan for the carrying out of the proposed improvement in the banks of the river, and something that would make a beautiful water park on this river.

Mr. STORROW. Bishop Lawrence, who is here, has taken an interest in this subject for a long time, and he has been kind enough to come here this morning, and I trust that he will speak to the committee.

Bishop LAWRENCE. Mr. Chairman and gentlemen, I will speak rather personally, as representing a great body of persons who have lived on the banks of the Charles River. I have lived on the banks of the Charles River practically all my life, or else under its influence, — whether at Cottage Farm or at Cambridge or in Boston. I have seen it develop from a comparatively clean river into a cess-pool, and now to be purified through the sewerage system, except so far as certain parts of Boston are concerned. I should like to speak a very few words on the desirability, taking my point of view from the three places that I have just mentioned, — Cottage Farm, where I passed my boyhood. All that one needs to do is to come down to the river at low tide and stand on the Cottage Farm bridge and see the acres of mud

flats which are exposed there, and to smell them. They are offensive to the sense, especially in the warm weather. A very narrow stream flows through the drawbridges. One may say, however, that in time all those mud flats will be dredged and thrown up onto the bank, and that this draw back at Cottage Farm will be obviated all the way up the river through the bridges. If one goes up to Cambridge, — I live in Cambridge, right opposite Soldiers' Field on Brattle Street. One of the most beautiful sites in Cambridge, to my mind, is the old gas house opposite Soldiers' Field, opposite Longfellow Park. I have been urged by some of the members of my family to sell out and to build on that site. It is my favorite walk in the spring and in the autumn afternoons. On account of the increasing width of the river there and the beautiful marshes, at high tide one is perfectly convinced as he looks off over the meadows and towards Mt. Auburn and the hills, and sees in the distance the hills and the woods and the beautiful sights, — he makes up his mind that he will go and ask the gas company what their price is and buy the place. But at low tide perhaps he feels inclined to change his mind. He is not so sure, then, that he will ask the gas company what their price is, — not at all. It is a question on those days in my mind as to whether there is going to be a certain amount of water there, a continuous amount of water, or whether the river is to be drained, and whether people who are able to pay for that land are going to build there, or whether they will not go out there. Perhaps that consideration may be secondary, but it is financial; and to my mind it is a pretty heavy financial question, when one takes 7 miles of river bank on both sides, as to what class of people are to be allowed to hold the banks of the river, — as to what class of people, from the financial point of view, are to live along the river banks. So much for Cottage Farm and for Cambridge.

I now live in Boston, near the bank of the river, and the one point I wish to make in connection with this proposed improvement of the river is this: we never see boys and girls and children and others taking the pleasure in rowing up and down a river that they do take in paddling round a mill pond. There is more that is really pleasurable in paddling where there is no current than there is in rowing even on the smoothest river, especially for people who are not expert oarsmen or who are not water men. To my mind, one reason why the Charles River to-day is not used as a boating river by thousands and thousands of people —

two reasons, are, in the first place, that it is a pretty strong current, which, while it is not dangerous except perhaps under the bridges at times, yet it is uncomfortable for the people who are not water men. They do not like to be perpetually going up and down the stream, but they do like to paddle quietly along in smooth water, such as you have about a mill pond. Another reason is, the lack of beauty on the banks of the river on both sides. If the dam is built and the current of the river is practically stopped all the time except when it is flushed, I cannot help thinking that the point President Eliot makes in his remarks will be accomplished, and not only that there will be a beautiful park for hundreds and thousands of people to enjoy themselves, but that there will be a beautiful basin of water without a current, where tens of thousands of children, boys and girls as well as older people, men and women, can pass their afternoons and their evenings in the summer. One of the great safeguards of a nation is that the people of the nation shall be water men. We have, even though we live in Boston and are surrounded by water, no opportunities, practically no opportunities, for making the great mass of our people familiar with the water. They can see it, they can bathe in it at the harbor, but they cannot really and safely go out on it, and it is a very great consideration; and I know of no other place, except it may be Jamaica Pond or the other ponds, for the harbor does not supply the want, because of deep water and the dangers of the sea. It seems to me to be a great elementary question, as to whether we are to give to the hundreds of thousands of boys and girls and those who are to come an opportunity to become familiar with life upon the water, that thereby their health may be made perfect, and that thereby we may have, if you want to call it so, further apprentices for our merchant marines and for our navy, — for there is nothing like water to bring a great body of business onto the ocean.

Mr. STORROW. There is nobody in the city who can speak as representing the crowded population of the North and West Ends with more authority than the Hon. John F. Fitzgerald, who is present. For six years he represented the North and West End sections of Boston in Congress, and I would like to ask him to say a few words to the committee.

Hon. JOHN F. FITZGERALD. Mr. Chairman and gentlemen of the committee, I am very much interested in this project. President Eliot a few moments ago spoke of the North End Park, and of the great good that it had accom-

plished in that section of the city. I was born and reared in the old North End, and years ago I saw the great necessity of such public improvements there. When I was a boy there was no place whatever for us to play in in that section, and we had as boys to play in the middle of the street. We played ball in the middle of the street, and when we organized our teams we would appoint two captains to stand on the opposite corners and look out for the policemen, in order to give us the alarm when one was coming. Then I made up my mind that, if I were ever placed in any position where I could do anything, I would see to it that the boys of the North End were given playgrounds and places for proper recreation. I made up my mind then that the first thing I would do would be to provide a place for the boys and girls and the young people of that section of the city to amuse themselves, and to enjoy the same privileges that were afforded other sections. I was elected to the common council of Boston in 1892, and the memories of my boyhood were with me then, and I introduced an order providing for the appropriation of a half million dollars for a North End Park. Hon. Nathan Matthews was mayor of Boston at that time, and as chief executive he gave all the aid and encouragement possible; and with his aid we secured that appropriation, and the result was that the North End to-day enjoys one of the best playgrounds and parks anywhere to be found.

The members of this commission are probably familiar with what we have down there. The North End district has a more cosmopolitan population than any similar section in the world. At the last municipal election I took pains to make a canvass of the voting list. We have 455 persons native Americans; we have about 1,900 persons of Irish extraction or Irish-American born; we have 595 Italian-Americans or Italian born; we have 565 persons either Jews or Jewish-American people; we have 85 Scandinavians, 46 Portuguese, 55 Germans and 10 colored Americans. That shows the cosmopolitan nature of the population in that section of the city to-day. There are also in the North End tenement houses where more than 65 persons are crowded into one tenement of not more than eight or nine rooms; and every once in a while, the city is startled with a conflagration, where lives are lost; and the people generally are aroused to the conditions existing in the tenements, and the conditions to which the people in that section are exposed. It is only then that the people of the city and of the Commonwealth of Massachusetts generally are made

alive to the situation which really exists in that section of the city.

President Eliot has spoken of the scenes witnessed at the North End Park. I have been down there in the summer many a time, and if the day is particularly warm, there are frequently from 500 to 600 people waiting for an opportunity to get a bathing suit. There are no opportunities enjoyed in that section of the city for boat rides, because of the conditions existing and the dangers of boating in the harbor which have been referred to.

As Mr. Storrow has said to you, it was my privilege to be a member of Congress for six years; and one of the pleasant features of that life was to see the manner in which Massachusetts was always held up as one of the foremost States, not only in commerce and in manufactures, but in everything that went to make the people of this State and of the Union better; and last year, just before the close of the session of Congress, when the bill for the appropriation for the District of Columbia was before the House, a gentleman by the name of Roake from Missouri fought against an appropriation calling for public baths in the city of Washington. He said he did not think it was the province of the United States government to furnish free baths to people; and in reply to that it was pointed out to him by other members of Congress that Boston led in this matter, as she has always led in other matters; not only does Boston furnish free bathing facilities for her people, but that her free bathing houses were the best in the country, if not in the world; and that Boston's park systems were the best in the world; and that the attention which Boston paid to details of that kind gives her a pre-eminent position among the great cities of the world. It was also pointed out that our educational institutions rank among the foremost institutions of the world. Our Massachusetts Institute of Technology, our Harvard University, our Boston Public Library and the Boston Museum of Fine Arts, — all these things help our State and help our city in the eyes of the people of the country. As showing, for example, how that thing works, ten or twelve different times in the session people came to me to ask me the details as to these institutions. I think within the confines of the city of Boston to-day we have more scholars, more students within our gates than in any part of the United States; and I think that every effort ought to be put forth by the citizens of Massachusetts and of Boston to make Boston pre-eminent in that respect; and I certainly hope the commission will look at it in that way.

The population of Boston is changing tremendously. In the North and West Ends they are increasing tremendously, in South Boston and Roxbury they are increasing also very rapidly. The foreign element is increasing very rapidly in all directions. You can go down to the North End to-day, and on Fleet Street or along in Hanover Square and in that vicinity you may walk about there and never hear a word of English spoken among the people. The children of those persons are coming along, and they have got to be educated in American ways and in American ideas; and they have got to be taught that the best results for themselves and for the community are to be attained by making themselves better citizens; and there is no better way of showing them how to do this, there is no better way of doing this for them, than by giving them opportunities for cultivation; and if we do that for the generations that are to come, we can hope to see the perpetuity of the institutions that have been handed down to us by our forefathers.

Judge Dunbar. Where is this North End beach?

Mr. Fitzgerald. It is on Commercial Street, between the water front and Copps Hill; as President Eliot has said, it is directly opposite old Copps Hill burying ground.

Mr. Storrow. There is no citizen of this great metropolitan Boston who has done more to contribute to the welfare of the city and to its good name and fame than Henry L. Higginson, and I ask him to tell the committee what he thinks about the plan for utilizing Charles River basin.

Maj. Henry L. Higginson. President Eliot tells us that we want imagination, — that you want imagination. I would like to ask you, gentlemen, to pass a night with me in August at my house on the north shore, and then to come up with me in the morning, and feel, as I do, refreshed and happy, and as I am very glad to come up; and then be reminded that, while we have a pleasant night and a fresh morning, there are an infinite number of human beings who are living in a very foul and rotten atmosphere. The least we can do for those people is to give them the best possible playground we can, and the best opportunities for enjoyment and recreation. My cause for gratification that I do get this contrast is that I am reminded, without any exercise of imagination at all, that I am blessed and that they are not. The same is true here in our homes on the Back Bay. We get dust enough there to choke us, it is true, but that can be remedied. I suppose there is nothing better that we can do towards keeping people tolerably well than to give

them plenty of sunshine and relaxation after a hard day's work. It is the best thing we can do for them, as human beings and as citizens. If I lived down in those crowded tenements, I suppose the first thing in the morning I would do would be to go and get a drink just as soon as I got up, and then I suppose I should get another one, and then I suppose I should probably have another as soon as possible, and then another, and very quickly the human being would be drunk; and I never wonder, when I see drunken people down there, because they have got to drink to drive off the nausea.

Mr. Fitzgerald says that we have the greatest opportunity for improvement in this country, and I think that is so. I think the nation would laugh if they came here and saw this chance we have to refresh and improve everybody, and yet how little we have used our opportunity. We have been trying for years to do so, and there is a park to our hands, — the best park we can possibly get; and yet we do not embrace the opportunity to use it. There is not half as much fun walking up and down on the sea shore and looking at the water as there would be for people to go out on the water and enjoy it, as they would do if we would give them a beautiful water park, where they could go boating, rowing and improving themselves physically and in every other way. At any rate, there is a place where they can be refreshed and amused, and boats going up and down, as they would be on any other great water park; and where they can laugh, and where the youngsters can tumble off into the water and be pulled out, — and I can assure you it is not the worst thing in the world to get a ducking. There is the place there for bath houses, where the boys and girls and the men and the women can go in and enjoy the water, and where they can go and skate in the winter just as much as they like; there is a place where they can start and go away up into the country in their boats, or skating on the ice; and yet — just think of it — we leave those grand opportunities in the condition in which they have been in, and we have done nothing to embrace the grand opportunities for making the finest water park in the world. We think, we Yankees, that we are as smart as lightning and yet we just let this wonderful chance go by. Any foreigner coming here would naturally say, "Why don't you use that sort of thing?" and yet people stand up and block the opportunity. If the few people who oppose this kind of thing are allowed to block it, it will be a very sad result, I think.

Now, as to the matter of whether the harbor is going to be injured, that you gentlemen will settle. You will understand that matter entirely; but I should think it was a very grievous thing if we do not remember that, while some of us have three meals a day to eat and a good place to sleep in at night and strawberries and cream, there are a good many people who do not have strawberries and cream or three meals a day or any especially good place to sleep in; and we certainly had better give them their strawberries and cream, if we can.

Mr. STORROW. The chief opposition, so far as I am aware, to utilizing the Charles River basin has come from people living on the water side of Beacon Street. But there are a few gentlemen who live on the water side of Beacon Street who favor this project. Mr. Matthews, long before he became our counsel, when he was mayor of the city, spoke in one of his inaugural addresses of the opportunity which was here being neglected. Mr. Matthews lives on the water side of Beacon Street. We have another gentleman here who lives on the water side of Beacon Street, and who has raised his voice several times to aid us in securing the passage of the act leading to the formation of this committee, and that is Mr. John Shepard.

Mr. JOHN SHEPARD. Mr. Chairman and gentlemen, I do not think I can say anything to enlighten you on this subject, but I certainly desire to endorse all that has been said in favor of the project. I am heartily in favor of it. I cannot possibly conceive how any one can object to it, certainly any one who has ever lived in that vicinity or who ever drove over the mill dam. I have lived there over twenty years, at the corner of Exeter Street, and previous to that at Hyde Park, and I certainly know by experience the terrible stench. Perhaps I have not noticed it so much in recent years. I don't know just why I don't notice it so bad now as in former years, but there has been some change there. They say it is because I own land there; perhaps that's it. I really haven't noticed it so badly of late. But, whatever the reason is, I believe we have here at our hands one of the most beautiful places in the world; and I cannot understand how anybody can for one moment object to our beautifying it, or object to our constructing a beautiful water park there. I think it ought to be pushed with all possible energy. Of course you have looked into the matter, and you know just what difficulties there are in the way. I hope you will not hesitate to make this great improvement, — and I do not

ask you to do it for my benefit, because in the summer I am not in Boston; for about six months in the year I am not in Boston, and so I do not ask you to make this improvement for my benefit; but I believe it is for the interest of the great city of Boston that this improvement should be made, and I hope you will push it forward with all the energy possible.

Mr. STORROW. Besides the North and West Ends, where there is a dense population, there is also a very large population in the South End, thousands and thousands of people living there who I believe would be glad to utilize the Charles River basin both in winter and in summer, if the project is carried out for making a water park. I would like to ask Mr. Robert A. Woods to speak to you. Mr. Woods is a graduate of Amherst, who has been living among these people for the last ten or twelve years in a settlement house in the South End, and studying their lives and doing good works, and writing books about what he has seen.

Mr. ROBERT A. WOODS. The South End has a certain claim to be heard in this matter, which is, in a certain way, superior to the North and West Ends, because it has a larger territory and a very large population, — possibly not so crowded, but still a very large population. There is no water front available in that vicinity. I have had that fact called to my attention very much, as a member of our public bath commission. It has been one of the greatest difficulties with us to determine how to provide for public baths for that great population of 100,000 or 150,000 people living near the geographical heart of the city. We have been able to provide two small bathing pools on the lower side of Roxbury; those two little bathing pools represent the only opportunity that that great population down in that part of the city has in the way of swimming facilities. A year or two ago the city put a playground on Columbus Avenue; and I should like to ask this commission, in the real or imaginary visit which they are to make, to include that playground during the skating season. If they could see how eager the grown people as well as the children of this section are to have some sort of opportunity for skating, they would be convinced of the need of this water park project. This is not really very far from the Charles River. In a short walk any person living in that section could reach the Charles River for the purposes of enjoyment in rowing or skating. The people of that section are very much interested in these matters, and we

expect this evening to have in the South End a public meeting in a public hall, and Mr. Storrow is going to come and explain just what the project is. In connection with all this work of supplying public playgrounds and baths in the city, I may say that I believe, in addition to doing a great deal for the improvement of hygienic and sanitary conditions, it has accomplished more perhaps in the way of stimulating public spirit in the people than people understand. There is on Dover Street a public bath house, and there have been some 300,000 baths taken there in the past year. That bath is open all the year round. There is moving along with this work in the minds of the common people an idea of the dignity of public institutions. It seems to me that, in addition to the health-giving influence, that building has accomplished wonders in the way of touching the imagination of our people, and strangers to our country and to our ideas, who go there and find that the city is touching them at a point of conscious need; and it gives them a new idea of what it means to be a citizen of such a city and of such a country. It seems to me that that is an opportunity in the way of fitting in a kind of keystone to our public community life, — a keystone which would complete the arch of social life on the two sides of the river, and which would impress all of those people who need the thing so much, — it would impress their imaginations, and give the young people as they are growing up an idea as to what metropolitan life really means; and I think that same argument would hold very strongly in regard to the constantly increasing number of strangers who come to Boston to see what they consider the sights of the city.

Q. (by Mr. Dunbar). How far is this district of which you speak from City Point? Is it a half hour's walk? A. Yes; most of the people could get there in half an hour.

Q. How far is it from that beach down towards Harrison Square? A. Well, the people on the eastern side of Roxbury could get to the Dorchester beach in half an hour.

Q. Could most of the people of whom you speak get there in half an hour? A. I should say that half of the people could get there in half an hour.

Q. Is the Dover Street bath a public bath? A. Yes.

Q. Is it a large one? A. It is not a swimming bath; it is a shower bath.

Q. Is there any other beach in that vicinity than this to which I have referred? A. No, I think not.

Mr. Storrow. Congressman Fitzgerald has aided the imagination of the committee by giving them a statement

of the foreign-born voters living in his old district. As the committee know, there is living in that section of the city a very large Italian population, — people who have come over from Italy and have thrown in their lot with us. They are going to be American citizens, and they are going to vote with us. One of the leaders among the Italian population is Mr. Joseph DeMarco, the editor of the Italian paper of Boston, and I will ask him to say a few words.

Mr. JOSEPH DEMARCO. Mr. Chairman and gentlemen, in the first place, I wish to apologize for my English, but I will try the best I can to express my opinions. My people at present are poor people in Boston, but still I think they have given their tribute to the welfare of this city, so I think a voice from one of that class might be opportune at such a time in favor of such a grand scheme as the proposed Charles River water park. In Italy the people usually enjoy open air. The higher classes have their own villas, the middle classes enjoy the beauty of the parks. In the crowded cities of Italy the villas of the rich are thrown open to the people, that they may visit them and roam at will. All Italians are very fond of open air. People here who live in the very crowded sections of the city do not enjoy the privileges which the people in Italy enjoy. It is necessary that the people should have plenty of light and air. I see many of the Italian people visiting the Common and the Charles River Park, and the poorest people go there, lost in contemplation. You cannot imagine how they enjoy it. While probably their clothes are shabby and all that, yet they enjoy the chance to visit in the public parks, and they would enjoy a Charles River Park. It is not merely painting or statuary that they enjoy, but I think those people would enjoy any park which would be laid out on Charles River. I know in Rome and in others of the large cities in Italy the private villas of the rich are thrown open to the people, especially on Sundays and holidays, and the people roam through those villas at will, and they certainly enjoy them. The people come from all of the poorest quarters and throng the private villas of the rich, and they wander about, showing how they thoroughly enjoy the opportunities for recreation which are offered by these noblemen in throwing open their parks for the public. So I say that any such opportunities afforded to the people would be welcomed, and would be a benediction to our people who come here and enjoy the privileges of this glorious country. That is all I have to say.

Mr. STORROW. Mr. Samuel F. Hubbard, the head of the

North End Mission, has spent his life working in the North End, and he knows all about the people and the needs of the people living in that section of the city, and I shall ask him to speak.

Mr. HUBBARD. Mr. Chairman and gentlemen, it is the North End Union, and not the North End Mission. One is heterodox and the other is orthodox. I am heterodox. But I am immensely interested in this question. Benjamin Franklin in his will left a large sum of money to the city of Boston, and, in determining the things for which it should be spent, spoke of fortifications and bridges, and ended up by saying, anything that will make the city more attractive to the stranger who is visiting the city. That was a good thought then, and it is a good thought now. What shall be done with that Franklin fund does not concern us very much at the present moment; but it does concern me very intimately as to what opportunity can be given to the thousands of boys and girls who are within a radius of a mile of the North End. You all know what a boy is. He is a good dynamo, but he is a mighty poor storage battery. The power has got to be utilized. The energy of the boy is like gas. The more you compress him, the more danger there is in him; but you give him an opportunity to expand and to expend his energy in proper ways, and you get good results. We sometimes speak of it as physical and moral education. I like to think of it as giving him a chance. The boys ought to be given a chance. Heredity ends with birth. The compulsion of environment takes it up right there, and the boy is largely the outcome of his environment; so that, if he can only have facilities and opportunities, such as this park would offer, in the way of enabling him to use up his surplus energy, I can guarantee you that it would be the very best investment that the city of Boston can make. It is not necessary for me to amplify this question. If it is desirable to inquire further into this, I would suggest that perhaps the record of Rainsford Island and the Lyman School might be looked into.

Then another matter to be considered is the value it would be to adults who are living in those congested communities. You remember the experiments tried by Heber Newton of taking these people and sending them out into the country, but it was not a great while before they gravitated back to the city. They said that the reason why they came back to the city was that it was so awful still in the country. Now, do they want still life, or do they want something that carries with it activity? It is the live pic-

ture that they are after. Now, if you have this water park, that will be just the picture that they need, filled with its fleet of puffing little steamers and its row boats and sail boats and all that, — it will be a perfect live picture; and you will find that these people will simply line the shores, feasting themselves on the pleasure that that picture will give. What those people want is more life, more abundant life; and I think this project will help very largely in that direction.

Mr. STORROW. Among that small corporal's guard of people who live on the water side of Beacon Street and who favor the plan of making a water park of Charles River is Dr. John G. Blake. I now ask Dr. Blake to say a few words.

Dr. JOHN G. BLAKE. Mr. Chairman, I come here as a physician and to some extent representing the sentiment of the physicians living on the Back Bay, three or four hundred of whom, I think, are in favor of this project. I live on the water side of Beacon Street and have lived there for six years, and I am exposed to many of the discomforts of this river which have been referred to in this hearing. Those odors and smells that we get there you have heard all about. We do get them, especially when the tide is out. I am not going to cast any discredit on Charles River, — nothing of the kind. I simply wish I had the imagination which President Eliot has, and that he could communicate it by vaccination, so that we might have it in even a modified form, to point out to you some of the conditions which exist there at low tide. He has pointed out what would be some of the advantages to the health of the citizens of Boston, and I quite agree with him. As an old oarsman, who is still very fond of rowing, — I row a great deal during the summer, — I find my efforts are greatly restricted at low tide. The river is by no means attractive, and at low tide the sanitary conditions there render it very undesirable. On the ground that this might be made a great source of pleasure to the people, and in the interest of the public health, I should strongly advocate placing a dam across the river, and making a water park there. I should advocate it simply on the score of health; and I think, as I say, that I represent the medical sentiment of the Back Bay and of the community at large, when I declare that it is desirable that something should be done; and it seems to me that nothing better can be done than the construction of such a dam as is proposed.

Q. (by Mr. MATTHEWS). At what number do you live

on Beacon Street? A. 212 Beacon Street, between Dartmouth and Clarendon streets.

Q. Are you troubled with odors there? A. We are troubled, yes, to some extent.

Q. (by Mr. DUNBAR). Those come from flats? A. Yes.

Q. Dredging would entirely obviate that? A. To some extent, yes; I think we ought to get at the source of the trouble.

Q. Does your idea involve a permanent dam, — a permanent body of fresh water? A. I think we ought to be able to empty it at any time, so that you would still preserve the flow of the river. The water might be let out at night, and in that way what might possibly have collected might be let out to some extent.

Q. The water would be fresh? A. We want the water fresh.

The CHAIRMAN. Is there anybody else who desires to be heard at this time?

JOHN N. MCCLINTOCK. Mr. Chairman and gentlemen, during an interview yesterday with Mr. Emery of the Harbor and Land Commission, he suggested to me that I should come here to-day and present certain views before this commission. I have written what I desire to say, and with your permission I will read it: —

If the sewage is taken out of the Charles River, absolutely, it is feasible to build a dam anywhere, with no bad results. The sewage should be taken out of the river from the fountain sources to the harbor, any way. As the river flows between Newton and Needham, near Newton Upper Falls, the water is drawn from it for domestic uses in Newton. At Auburndale the river is in a fair condition at present. No pollution should be allowed to enter it below Auburndale, in any case. When that is done, the dam can be built anywhere. There should be a lock and a fishway, of course. The only important point to be settled would be the height of the water above the dam. I am not prepared to give advice on that subject.

It might be well for the present to drain the marshes bordering the river, and convert them into productive land. They would not be injured by a spring freshet of fresh water. Taking the marsh level as 10, the surface might drain down to grade 7 with the ebb tide and fill up to grade 8¼ with high water. It would be better to either drain the marsh or to flood it. Of course the last would be the most expensive, as it would involve the purchase of the whole of it. That is a minor problem.

Boston harbor belongs to the whole United States as well as to Massachusetts. The general government has to be consulted in all matters affecting Boston harbor. It has been the custom, if not the written law, for many years, for the government to demand that all filling or making of land should be compensated for by an equal amount of dredging from the bottom of the harbor. This has been on account of the supposition that the current dredged out the channel

according to the amount of water that flowed in with the flood and flowed out with the ebb tide. The currents have very little effect on sewer sludge, however. It precipitates as soon as the current will let it, and when it gets to the bottom, it sticks there for good.

For the past fifteen years the State has conducted an experimental station at Lawrence. Lots of valuable information has been accumulated there. One of the most important facts learned there is the amount of solid matter carried in suspension by the ordinary sewage of a city. This has been found to average one-tenth of one per cent. of the bulk of the sewage. The sewage amounts to about 100 gallons per day per capita. There are about 1,000,000 people served by the metropolitan sewers. The district has 100,000,000 gallons of sewage per day to care for, or 100,000 gallons of solid matter, or 36,500,000 gallons during a year. This sludge when exposed to the air carries nine times its bulk of water, and fully as much when it is immersed beneath the water. Therefore the district is depositing in Boston harbor, during a single year, 365,000,000 gallons of the most offensive mud. There are 7½ gallons to a cubic foot, so there are deposited 48⅔ million cubic feet of mud, or 1,800,000 cubic yards of mud. As undoubtedly some of the water gets pressed out of the sludge by the weight of that deposited above it, it may be wise to reduce the estimate 50 per cent., making 900,000 to 1,000,000 cubic yards of solid matter deposited in the harbor in the course of a single year. Supposing the Charles River to average 12 feet deep and 180 feet wide, do you realize that that amount of mud would make a Charles River of mud over 2 miles long, or 12,498 feet? If the sewage is taken out of the Charles River, it will compensate largely for the loss of scour of the current from the river.

A Boston pilot lately reported to the press that he found 3 feet less water in the channel than the coast survey charts called for. I know what skill is used in making those charts, — I have made many of them myself. They are absolutely right. Probably the pilot was right. If a million cubic yards of mud is put into Boston harbor every year, it is bound to show somewhere in time. A few years ago a water main was laid out to Long Island. A vessel fouled its anchor and broke it, the water main, so that it had to be repaired. The original diver who laid the pipe was engaged to do the work; and he reported that an accumulation of 3 feet of mud had settled over the pipe since it was laid. Mr. James H. Stark is my authority for this story. I saw by the plans of the South Union Station that there was a deposit of about 18 inches of mud in the harbor in that neighborhood. The settling of the "Maine" in Havana harbor indicates that the sludge does not lose its moisture.

Is it any wonder that when the late Amasa S. Glover called me into consultation to perfect his apparatus for making sewage inoffensive, both on the land and on the sea, I thought it my duty to investigate his claims? I consider Mr. Glover one of the greatest benefactors of his race that ever lived. He showed how it was possible to build the Charles River dam, and how it is possible to make Boston harbor the most beautiful body of water in the world. He showed how Massachusetts could take the sewage of Lynn out of the ocean, and not dilute with sewage the water offered to the poor people of Boston for bathing purposes at Revere beach. Salt marsh naturally is not offensive, — I have camped upon it for weeks at a time; but the salt marsh at the mouth of the Saugus River in July, August and September is a place of horror, on account of the Lynn sewage. The effect of Deer Island sewage is felt down to Scituate.

Let this Legislature take the sewage out of Boston harbor, and Congress will give an appropriation for deepening the harbor that will make every merchant smile for the future prosperity and growth of Boston. Leave it in the harbor, as it is to-day, and you break a United States statute, made and provided for just such cases, and your appropriation comes very grudgingly. There are certain Senators who can read understandingly of the experiments conducted at Lawrence by the State Board of Health; and when they enact, as they did in 1899, that the solids in the sewage should not be allowed to be deposited in any navigable water of the United States or tributary thereof, they wish to see their laws obeyed. When these engineering problems are entrusted to a responsible and paid commission, say like the Harbor and Land Commission, Massachusetts will not be making any more blunders, like condemning Mr. Glover's great discovery, without at least some sort of investigation.

The street gutters of Norfolk and New Orleans were formerly used as open sewers. That seems rather primitive. It is not more so than Boston using her harbor into which to dump her sewage. It is a suicidal policy, and the sooner the people realize it, the better. If a tank is built large enough to hold only one day's flow of the sewage, 90 per cent. of the dissolved impurities will be eliminated, and 95 per cent. of the suspended matter. Think of it. With a proper filter, twice as large, practically all of the offensive matter is removed; and the wonderful part of the whole is, the solid matter eats itself up. Manchester, London, Birmingham and many other English cities are using this system to-day. Commissioners from New Jersey and Connecticut have recently visited the old country and came home and reported, as I have to you. The system is working on the estate of Samuel Johnson, in the town of Milton, within 7 miles of the State House.

Opening by James J. Storrow.

Mr. Chairman and gentlemen of the committee, I am here simply as a citizen of Boston. Mr. Matthews, our counsel, has suggested to me that I ought to make a general opening statement to the committee, outlining in a general way our views or prejudices or opinions in regard to this subject. As I am not a technical expert, I do not know whether I can aid this commission. This subject has been agitated for a good many years quite actively, as has been stated, for thirty-three years, a third of a century; and it is to be hoped that this committee will stop the agitation, for the sake of all of us, — that it will report either in favor of utilizing the Charles River basin, and give sufficiently good reasons to appeal to the general sense of this community, or that it will report against the desirability or feasibility of using the Charles River basin, and give sufficiently good reasons to satisfy the different citizens who have been interested in this matter, so that this agitation will come to an end.

Possibly, therefore, it may be of use to the committee for me, assuming that I am a sample citizen, a sample of

ordinary intelligence, to state to the committee in a general way my views, what ideas I have on the subject, what prejudices or opinions I have; and then the committee in their report will either combat them or point out the errors or possibly find some truth in some of them. But if the committee fails, when it makes its report, to make its conclusion and the grounds for it clear and intelligible to me as a sample citizen, that is to say, to the average citizen, then this thing will be up all over again. This is the third or fourth commission that has dealt with this subject, and we will have more commissions, unless this committee takes up the subject and gives not merely a yes or no, but makes the matter sufficiently plain so that the ordinary citizen can understand it and be satisfied as to the justice of the result. From that point of view, therefore, possibly I may aid the committee, if, as a sample citizen, I lay bare my mind on this subject.

We could easily have filled this room four or five times over with citizens who would be glad to come up here and testify to their interest in this matter, as we did when the appointment of this committee was before the Legislature; but I understood in a general way from the commission, and I assumed from the intelligence of the commission, that it would not be helpful to carry that beyond asking a few leading citizens, whom we all recognize as having in mind the public good, to come here and speak for the hundreds and thousands that stand behind those gentlemen whenever they do speak. I would like to call your attention to the fact, however, that when we had this matter up before the Legislature last spring, the citizens who interested themselves particularly in forwarding the matter sent out some circular letters, asking a number of citizens whether they favored the idea of utilizing the Charles River basin, if it was found practicable. To that circular request for opinions the committee received a great many written replies, and I am going to present those letters to this committee. A great many of those letters are very interesting. It was not at all the case, as is sometimes done, of hiring men for two or four or five cents a name to go around the city and take a seat in peoples' offices until they got their signatures or else are put out; but practically every letter or postal card that has come to us has come simply in answer to a printed request sent by mail for the opinion of the man to whom it was addressed. I think we have here about 2,000 letters, written by different people, all sorts of people here in Boston, manifesting their desire that this

thing should be done. In addition to that, I think we have 5,000 or 6,000 postal cards, from different citizens who have written on the postal card that was enclosed with the circular asking for their opinion. Some of these letters — obviously I can't read all, and won't attempt to read them extensively — are very interesting, and I hope the members of the committee will be able to devote some attention to them, because they set forth many different points of view, and seem to me well worthy of perusal.

The first letter is from Mr. Charles Francis Adams, and Mr. Adams' views are intelligent and intelligible, and I think worthy of perusal. The next letter is from Mr. Uriel H. Crocker. He brings out in his letter a point of interest, and that is, that in 1869 he wrote a letter to the Boston "Advertiser," advocating the construction of a dam at Craigie bridge. That was thirty-three years ago. As the result of that letter, written in 1869, there was a very active agitation of the subject at that time, to which I will call your attention later.

The next letter happens to be from a landscape architect, Mr. Warren H. Manning, who says that his business, taking him all over the country, brings him in touch with a great many people whom he knows are often brought to Boston by the general attractiveness of the city.

The next letter is from Mr. Henry A. Wyman, who states that he lives on the slope of Beacon Hill, and that he has always been much interested in this subject; and that in 1899 he went to Hamburg for the express purpose of looking into the improvement there made, and looking at that basin and considering the applicability of the treatment there given to the basin to Boston conditions.

The next letter happens to be from a doctor, Dr. Burrage, who also speaks of the fact that he has been in Hamburg, and has been very much impressed with the beauty of the basin there, and doesn't see why we don't do the same thing here.

There are numerous other letters here, — probably a dozen letters from gentlemen who have seen the Hamburg basin, — besides hundreds and hundreds of others; and, partly for the sake of relieving the press of matters on this desk, I will present all these letters to the committee. I think there are altogether some 7,000 letters and postal cards. I hope the committee will read them all.

Now, in considering our evidence and method of presenting it, I suppose that, if this hearing were conducted as a court of law, it would only be necessary for us to ask a

certain number of citizens (as we have already done this morning) to come here and tell you of the desirability of utilizing this basin; then we would rest our case, and we would ask the gentlemen who were opposed to the utilization of this basin to present their objections. But we have understood that the committee do not desire us to proceed in that somewhat technical manner, and therefore we are going to endeavor, as a part of our opening case, to present fully an outline of our whole plan, and also, so far as we are aware that they exist, to meet any objections that have been raised by anybody against the general plan. We are somewhat embarrassed in doing this, because the ingenuity of some of our friends who are opposed to this may have enabled them to conjure up some new objections since this matter last came up. Furthermore, we do not know just what emphasis will be laid upon one objection as compared with some other. Therefore, when it comes to reply, we will ask the committee to give us a very considerable degree of latitude.

On the general subject of the desirability of this plan for turning the Charles River basin into a water park, I think I can add but very little to what has been already said this morning. It seems to me perfectly obvious that we have here in Boston a grand opportunity, which it is absolutely short-sighted and absolutely foolish, and absolutely wrong for us to neglect. It has been said — I think by the chairman of the Metropolitan Park Commission, who has studied this matter a great deal — that the Charles River basin ought to be the court of honor of Boston. I believe that is true. That water front ought to be the chief place of resort. As President Eliot said, to appreciate the force of that argument requires imagination, as everything in the world that is worth doing, whether an engineering problem or anything else, requires imagination.

Besides the fact that the basin, if properly treated, would add tremendously to the dignity and attractiveness of Boston, there is the other point of view; and that is, the outdoor and playground point of view. The basin is the centre of the whole metropolitan population. The city, or the State through its various boards, has very wisely looked ahead for future generations, and has bought large tracts of land on the outskirts of the city; but it is true, I think, that a park diminishes in value at least as the square of its distance from the population it is to serve, not in arithmetical but at least in geometrical progression. It is perfectly impossible for the small children of the North End and West

End of the city, for example, to find their way out to Franklin Park once or more than once or twice in their lives; and, as for Franklin Park furnishing an ordinary playground for those children, it might as well be in another planet. The same thing is equally true when you speak of half an hour's walk to any playground. Those children can't walk for half an hour, — two miles, — to utilize a playground; it must be near them. It seems to me that that is the greatest significance of this basin, — that it is in the very centre of our densest population. We have on the eastern side the densest population in New England and probably in the United States, — the North and West Ends. We have in the South End a large population; we have on the Cambridge side, particularly in East Cambridge and Cambridgeport, a dense population, always growing denser. Tenement houses are going up rapidly. I don't know where the process of crowding people on to this land is going to stop, but it is still under full headway at the present time. The fact that this proposed water park is in the very centre of our population is of enormous importance; and the fact that there are other parks at a considerable distance — half an hour's ride on the cars, fifteen or twenty minutes on the cars — does not meet the question at all.

I had occasion, on an afternoon stroll three Sundays ago, to wander out through the Fenway and to visit Jamaica Pond. I had not been to Jamaica Pond for some years during the skating season, and I was perfectly amazed to see the number of people that Sunday afternoon (it was about half-past 3) who were skating on that pond. I had no means of counting them, — the scene was so animated and the movement so swift that it was impossible to count them; but I think it is perfectly safe to say that at half-past 3 that Sunday afternoon there were at least 2,000 people skating on Jamaica Pond. I stood at the principal point of access to the pond, and there was a constant stream of people coming on to the pond. It looked almost like the stream of people we see coming from one of our big railroad stations. I couldn't stay long, but while I was there the crowd was being augmented rapidly. I believe it is not too much to say that on that pond lying way out there on the outskirts of the city at least 4,000 people were skating on that Sunday, taking the morning and afternoon together.

Now, the population out there at Jamaica Pond is comparatively sparse, and the pond is not accessible to the people of the city; they have to ride out in the steam cars

or take a long ride on the electric cars. Now, if on that Sunday 4,000 people were using Jamaica Pond, way out there on the outskirts of the city, far from the centre of population, how many people during a winter holiday or Saturday or Sunday afternoon would use the Charles River basin for skating? We would have a basin 8 miles long, from the Union boat house to the Watertown dam. This is another case requiring imagination; but it seems to me it requires very slight stress of imagination to compute that the number who would utilize that basin would be at least five times the number that were skating on that one comparatively small pond, located way out there on the edge of the city. It seems to me that on a fine winter day there would be at least 20,000 people utilizing that basin, and, for aught I know, it might be 40,000. But it seems to me in your report you would be well within bounds if you should find that at least 20,000 people would use that basin on a pleasant winter's day. These are some of the things that we hope this committee will consider and report upon, because this is one of the questions this matter turns on.

Now, from the point of view of the commercial aspect of that basin, what is it worth to Boston to make that basin what it ought to be? Anybody who has lived in Boston any length of time knows that Boston is proverbially a place where the hotels are full all the year round. I think, if you consider that for a moment, you will readily see the reason. During the summer Boston is the gateway to the most beautiful part of the country, — the most attractive part of the country for summer residence. An enormous number of people from all over the country go down to Cape Ann and Cape Cod; then we have the places stretched along the coast of Maine, a thousand pleasant islands and hundreds of miles of beautiful shores; we have the White Mountains, the interior country of Maine, with its lakes and forests and streams; then the Provinces, which are growing more and more in favor. The number of people who pass through Boston every summer is tremendous, and it is increasing with great rapidity. If we can persuade, if we can induce, but a comparatively small percentage of these people to stay in Boston, attracted by its dignity and beauty, for only a day or two apiece, it means a tremendous lot of money coming into Boston. Look up and down the Atlantic coast, look at Galveston, New Orleans, Savannah, Charleston, Baltimore, Philadelphia, New York, — and what city in the whole lot can vie with Boston as an attractive place to visit

during the summer? It is the most attractive city in the entire — I don't know what the distance is, but for the several thousand miles of Atlantic seaboard. People naturally have a reason to come here or pass through here in the beautiful coast beyond; and if an increasing percentage of those people get in the habit of stopping in Boston, if only for a day or two apiece, it means hundreds of thousands of dollars and it may mean millions of dollars a year to Boston. Look through the western part of the country; take places like Omaha, St. Louis, Chicago, Pittsburg, Cincinnati, — I don't know that I ought to say it except confidentially, but I have had the misfortune to be in all of those cities during the hot season of the year. The extreme heat and the intolerably smoky atmosphere render them terribly unattractive during four months in the year; and it is with the greatest joy that I have escaped back here, even though my days were not to be spent down on the coast of Maine, but in the city. It is natural, and it is a movement that can be carried much farther than it has been yet, to get those people into the habit of staying in Boston a week or a few days every summer. The habit is growing, and the beauty and attractiveness of this basin can be made to help. These strangers won't find anything equal to it in any other city on the continent. Therefore, I believe that to Boston this matter can be measured only in some hundreds of thousands of dollars, at least, every year.

That this sort of thing is of real commercial importance to a city, we can all readily appreciate if we take the case of Paris. Paris is a city without any, so far as I have noticed, striking natural advantages. The climate isn't particularly attractive, there is no especially fine scenery there, there is no especially grand river there, — nothing like as noble or as pretty a stream as we have here. Altogether, there is nothing especially attractive about either the climate or the physical characteristics of Paris; but, as a matter of fact, people flock to Paris from all over the world, millions and millions of dollars are spent there every year. People crowd the almost numberless hotels, they live there for short times, or they take up their permanent residence there. They frequent the shops, and when they get back home they send to Paris for things they saw in Paris. It means millions of dollars every year to Paris. That is merely the natural result of a systematic and intelligent effort to make and keep beautiful a city without the natural advantages we have here. The commercial importance of that is great, and amounts to millions of dollars a year.

We can do the same thing here. Boston is now known throughout this continent and all over Europe too as a great musical centre, thanks very largely to the public spirit of one citizen in establishing and maintaining an absolutely unrivalled orchestra. Boston has also come to be known as one of the great educational centres of the world. Now, if, in addition to these things, at a reasonable expense and by a far-sighted development of this great natural physical advantage, we can tip the scale in our favor, and cause our city to be recognized as the most dignified, the most noble, the most beautiful in America, then I would like to ask what that is worth in dollars and cents.

It does not need, it seems to me, any enforcement upon your attention that at the present time the basin is absolutely not utilized for any purpose. We turn our backs on it. There [indicating photograph] is a view taken behind the houses of the gentlemen who are opposing this movement, and the time wasn't selected, so far as I am aware, to send the photographer there. You will see from that picture that at that time there was just one solitary person on that entire river front. That is a fair sample of the extent to which we are using what ought to be the most beautiful, the most attractive, the most frequented part of this metropolitan city.

Now, here is another view [showing picture of another portion of that river front], taken over in Cambridge. That is as far as the intelligence of Massachusetts and Boston has brought us as yet. I don't think we ought to be content to stop with this, unless there is some engineering difficulty with which human intelligence is unable to cope. We hope to satisfy you that human intelligence can cope with a great deal more serious difficulties than are involved here.

[Showing third photograph.] There is another portion of that beautiful basin, taken not at one of its most beautiful moments. Those are the flats. I think that is taken on the Cambridge side, looking toward Bay State Road.

[Showing fourth photograph.] There is another view, showing what we are doing. This is back of the Beacon Street houses. This is all flats here, and they extend out to here.

[Showing fifth photograph.] There is another view, taken back of the Beacon Street houses, showing two of the private sewers which are pouring their filth into what ought to be the heart and lungs of the city. One day when I spoke to one of the gentlemen living near that block about this matter, and asked him if he didn't feel like

favoring it, he said never, for he considered the right to drain into that basin "a priceless privilege."

[Showing sixth photograph.] This picture represents the way that Hamburg has dealt with a problem very similar to ours. I wish I had seen that Hamburg basin; I never have had the opportunity. But one thing that strikes me about it, is the fact that that shore line is almost equivalent to the one back of Beacon Street. It is really a perfectly straight front. The straight line has been fringed with trees and broken by these little parks here and there, little rounded points, which give a most beautiful effect to the water front, — a very simple treatment, a shelving shore with its winding path and trees, and these little points. So much for the general æsthetic opportunity which we so far have refused to appreciate or utilize.

[Showing seventh photograph.] As to the playground part of it, here is a picture taken on the Thames at Henley during one of the Henley regattas. I don't know the distance from London, but I think it is about three-quarters of an hour on the steam cars. I have been there. Sometimes the river looks even more crowded than that. I have journeyed on the Thames from Windsor nearly up to Oxford. It is a most beautiful stretch of river, though not one whit more beautiful than the Charles can be, if we will let it. If you go there on Sunday or a holiday, as I have been several times, you see a countless procession of people passing up and down the river in a constant stream. I have no way of estimating the number of people going out there from London on a holiday or Saturday afternoon or Sunday, but I know the trains are very, very crowded, and when you get to the river, whether at Windsor or forty miles above it, you see this same constant stream of people passing up and down the river, who have evidently chiefly come from London.

[Showing eighth photograph.] Here is a picture of the Alster basin, showing the way that is being utilized for boating purposes.

It has been asked why, if we want to turn this basin into a water park, is it necessary to build a dam? Well, I think there are a variety of reasons why it is necessary to build a dam. In the first place, a rise and fall is certain to lead to an unsightly wall. It needn't necessarily be as unsightly, of course, as the wall in that photograph, with those private sewers sticking out of it, but still it cannot be really attractive. I myself have lately gone a number of times over on the Cambridge side of the river and walked up and down

along that Cambridge embankment, where Cambridge has taken, as far as lay in its power, the steps necessary to improve the river front, but I can't say that it is a particularly attractive walk. If you go there at low tide, although the flats near the Harvard bridge have now been pretty well dug away and put in behind the wall, yet there is really nothing very beautiful or attractive about it. The water is way down below you there, at the foot of a high and necessarily slimy and rather dirty stone wall. You can see the water down there, but you can't get near it and you know you can't touch it, and the general effect is uninteresting and rather unattractive. Compare that with the winding path along the clean, shelving shore of the Alster basin. In one place it is a pleasure to stroll, and in the other place I know it hardly is a pleasure. I find it more pleasant, myself, to take the walk that goes out through the Fenway, where the path does as a matter of fact go along the water's edge, winding along the contour of the shore.

Then, again, take the question of the winter use of the park, the ice. I have seen that basin all my life. We all know that the basin is not used, because it cannot be used, for skating. I know that from my own observation; everybody knows it. Who has seen a solitary person skating on that basin this entire winter? Yet how we see people crowd on to that pretty, perhaps, but stupid little Public Garden pond. If you want to get 20,000 or 40,000 people out on the surface of the basin to enjoy the fresh air and sunshine, you must check the current and let the surface safely freeze. It would also help if during the cold months the water could be freshened; but the most important thing is to check the currents.

Then, take boating. The ordinary boat, such as you see on the Thames with a holiday party in it, must necessarily be a wide, safe boat. The paterfamilias and the mother and the four or five children can't go out and have any fun spending a day in a narrow, tippy boat, that is likely at any moment to upset. They have got to have, for the sake of safety and for comfort, a broad, blunt boat. Now suppose, under present conditions, this family goes down to the Charlesbank and gets a boat and starts to row, — father and mother and children in that boat, — what do they do? We will suppose the tide is on the ebb. They have not been out two minutes before they find the tide is taking them directly down to the railroad bridges, and the only thing the father can do is to take the oars away from the children, sit down on the rowing thwart, pull off his coat,

and go to work. As long as he rows steadily without stopping, if he has some skill at the oars, he can keep away from the railroad bridges and stay where he started, but that is all he can do. It is absolutely impossible, with the present tides, to use the Charles River basin as a general water park. If the tide is flood, our holiday family finds itself a mile or two from where they started, and they can hardly get back. The best thing they could do would be to go ashore, if it were possible to get the mother and children up that steep, slimy wall. If the basin is to be used, you have got to have the conditions that exist on the Thames. This also applies to the use of the harbor. It is totally impossible for ordinary unskillful people to go down to the harbor, where ferry boats are plying constantly back and forth, and where tug boats are rushing up and down, and use it for a holiday picnic. Practically, I think, while a good deal can be done at City Point, the use of the harbor as a water park will never begin to be as valuable as the use that can be made of this basin, provided the tides can be checked. Of course, in the condition of the basin to-day, if anybody does go down there they may find low tide. There is no fun in rowing at low tide. That alone prevents people from rowing, because the ordinary man won't consult an almanac, to see whether the tide is right or not. He gets in the habit of going to such a place, or not going there, according to general conditions. The consequence of this is, that the river is only used as a place of recreation by a few comparatively hardy and skillful experts. Women, children and holiday duffers need not apply. In winter it is so treacherous and unsafe that even the hardy experts do not dare to trust themselves upon its half-frozen surface.

There is one more point I would like to speak of, and that is the fact that this whole metropolitan district has absolutely committed itself to the proposition that the Charles River is going to be devoted to pleasure purposes. The city of Cambridge has spent a million and a quarter of dollars for improving its portion of the river front for park purposes. The city of Boston and the Metropolitan Park Commission have together spent a million and three-quarters of dollars. Those three parties — Boston, Cambridge and the Metropolitan Park Commission — have spent two million nine hundred and some thousand dollars, all based on the proposition that the Charles River is to be devoted to recreation purposes. That does not include what has been spent by Newton and other towns farther up. Every single

city touching the lower Charles has taken that point of view. They are irrevocably committed to the proposition that the Charles River is going to be used as a park. Those cities, by taking the fronts in their unimproved condition, —

Mr. DUNBAR. Will you tell us, please, what this expenditure is for, — improving the banks of the river?

Mr. STORROW. It has been for taking land along the river front or improving land thus taken. The amount thus spent is given in one of the late reports of the Metropolitan Park Commission. My impression is, it is the report of 1901. This picture [exhibiting a picture taken about opposite the old Harvard boat house] shows a portion of the river bank in Brighton, opposite Cambridge. I am not certain, but I think that is a part that has been taken for park purposes; I know there across the river it has been taken for park purposes, for that old coal wharf has been taken, and pulled down. This ugly, demoralized, ragged marsh edge is part of Brighton.

In thus spending three million dollars, this metropolitan city has committed itself, of course, to further expenditures along the same line. That ugly bank is not going to be left in that condition. They are going to pay out at the very least two million dollars more. I fancy it is not too much to say that Boston and Cambridge, directly or through the Metropolitan Park Commission, have committed themselves to spend at least five million dollars in endeavoring to beautify and utilize the Charles.

Now, as to the cost of a dam, — if this committee should decide that a dam is desirable. We have had prepared by our engineers plans which provide that the dam may be built (1) close to West Boston bridge, that is, the bridge at the foot of the basin; (2) or 600 feet above the Craigie bridge, which is the site proposed by the Joint Board in their report; or (3) as a substitute for Craigie bridge. I asked our engineers the other day to let me have the figures (so I could compare the cost of building this dam and the cost of building the new West Boston bridge) of what a dam would cost if we substituted our dam for the present West Boston bridge. That bridge, I understand, is to cost two millions and a half when it is done. It is a very large sum, and I suppose that at least a million dollars of that has been put on simply to make that bridge a beautiful structure; and it is another million which I haven't counted in the five millions I have just been speaking of. It is because it is felt by the cities of Boston and Cambridge that the basin is important enough to make it beautiful.

The tidal dam we propose will be for the most part a solid earth dam, with retaining walls on the upper and lower sides, in many respects analogous to and of the same character as the former dam proposed by the Joint Board. The surface of the dam, of course, affords a roadway for the passage of persons and traffic; therefore we are getting, for the expense of a dam, a dam and a bridge, — a bridge with a surface which needs only the repair of an ordinary road. So I asked our engineers what it would cost to build a bridge and dam of our type, if we put it right where the West Boston bridge is now being built, and I was told the sum would be only about one-half the cost of the West Boston bridge. Therefore, if we had had the opportunity to put our dam there, we could have saved at least a million dollars to the cities of Boston and Cambridge, and got the dam thrown in for nothing.

Now, our engineer has told us that the cost of building a dam at West Boston bridge and Craigie bridge is approximately — I am using words and figures that possibly he may not approve of — approximately the same, owing to the fact that at Craigie bridge the depth is much greater, the increased depth at Craigie bridge about making up for the increased length at the West Boston bridge. I have also been told that the Craigie bridge is a very old bridge and in a very dilapidated condition; the time is now come when it is intended in any event to rebuild it entirely; and if it be true that should turn out to be a good site for the dam, I believe that we can put a bridge and dam there for a sum of money which will show that we are getting the dam for nothing. It doesn't cost any more to build a bridge, if you like to look at it in that way, of that type, which will serve as a dam, than if we build a bridge of the type that is now being put on the West Boston site. If the commission should recommend the site 600 feet above the present Craigie bridge, obviously the use of the dam as a roadway will be of much less importance, unless, indeed, the present Craigie bridge should be abandoned altogether, and that site substituted for the present one; so that I believe it will be found by the committee that we can get the dam for nothing.

I furthermore believe that, if we don't have this dam, it is pretty well agreed by everybody that the basin at least must be dredged thoroughly, so that there will be no more flats of the kind indicated in the photographs I showed you a few moments ago. I don't know what sum it would take to dredge thoroughly the basin, so that no flats would be exposed, but I have heard it stated on good authority that

it would be $500,000. Whether some of the dredging that has lately taken place would diminish that somewhat, I do not know, but I think the present cost would be at least $500,000. Mr. Matthews tells me two and a half millions, but I won't put it higher than $500,000. Mr. Matthews says, on the authority of Mr. Jackson, the city engineer, it is going to cost a very much larger sum, but I will stick to the $500,000; the committee will have to find out the fact.

Then, as to the treatment of those shores. I have heard it figured, and I think there are figures in evidence before this Board already, showing that the saving in the treatment of the twelve miles of river bank — taking the two sides — above Cottage Farm bridge, if we keep the water at a constant level, will be over a million dollars; so that there is, I believe, at least a million and a half dollars saved by a dam, in addition to the fact that we are getting a dam for nothing, and a water park for which there is no price per square foot to be paid. The city is merely claiming its own.

Now, to turn to some of the objections that have been made. The State Board of Health has stated, in its communication to this committee, that the sewage now going into the Charles River is equivalent to the constant sewage of 3,400 people, — 3,350, I think it is; that of this number they estimate approximately 1,000 people live on the water side of Beacon Street, and are enjoying that "priceless privilege" of draining directly into the river. Of course no sane person contends that that condition of affairs in regard to those Beacon Street houses should continue indefinitely. We are going to stop that, whether this dam is built or not. An effort was made to stop it some years ago, and some ordinance was passed; but the gentlemen living on the water side of Beacon Street, I believe, appointed a committee, raised a fund, and managed to get the ordinance repealed; so they still enjoy the "priceless privilege" of draining into the face of this city, instead of a sewer, as the rest of us do. But the life of their privilege is drawing to a close.

I believe it has been stated, on the authority of the head of the sewer department of Boston, that an intercepting sewer running along the back of the Beacon Street houses would cost $60,000. That is a very small sum, of course. At an expense of $60,000 to be incurred by the city of Boston, that sewage can be entirely taken out of the Charles River basin, so that then we have to deal simply with the sewage of 2,400 people. I believe that it is generally accepted by sanitary engineers that a flow of 10 cubic feet a

second is a perfectly safe flow of water to receive the sewage of 1,000 people. Our engineer, Mr. Blake, who has been making a study of that question, will satisfy you on that point. I think the figures show that Charles River affords at least five or six times the amount of flow which the sanitary engineers of this country and other countries all agree is necessary to dispose with absolute safety of the sewage which is still getting into the river.

The problem, I believe, can be approached from another point of view, which is the mere gallons of dilution, apart from the question of looking at it as so many gallons of flow per second. The sewage which comes into Charles River, except the Beacon Street sewage, comes in under the most favorable conditions. The general atmosphere of the evidence before the Harbor and Land Commissioners, which the two ex-governors seemed to be able to maintain, was that there would be a *maximum* flow of sewage when there was a *minimum* amount of water in the river, — a condition of affairs which is impossible. You can only get the maximum flow of sewage into the river when there is the maximum flow of water. Take the ordinary thunder shower, when there is a minimum flow, which perhaps opens the gates only for an hour or two. The water quickly passes off the streets and is gone. The amount of sewage that passes into the river depends on the duration of the rain, and in the case of such a shower it would be trifling. But take the heavy storms, where the outlets into the river would be open a long time, perhaps twenty-four or thirty-six hours, an easterly storm or heavy southwesterly storm, then the river itself rises, the big meadows in Dedham entirely overflow with water, the meadows in Medway and Medfield overflow with water, and after the storm stops and the sewage has ceased to enter the basin the river continues a heavy discharge of water, emptying all those miles and miles of meadow into the basin to dilute the sewage, and beyond that still maintains a steady flow, — so that, when the amount of sewage that goes into the river is serious, then we have conditions very favorable for its reception. The first and immediate effect of a rain is to flush the sewers. That doesn't go into the river, but to Moon Island or Deer Island. The next effect is to tremendously dilute the sewage in the sewers before it is emptied into the river. I believe that that dilution averages 10 to 1 before the water is discharged at all. Then, — it is not possible, at least for me, to give definite figures, — but I fancy when the overflow gets into the river there is a

further dilution of at least 100 to 1 on top of the 10 to 1 which has already taken place in the sewers. I can't give figures, but I fancy there is a dilution of 1,000 to 1 at least, and perhaps more, whenever sewage is discharged into the basin. I have been told that it has been stated by eminent sanitary engineers that a dilution of 100 to 1 was a safe limit. Then the rain stops. What happens? The water continues to pour down from the water-shed in a continuous stream for the next four or five days, and if we started with a dilution of 1,000 to 1, every second and moment (at least within a very short time after that storm ceased) the sewage is being more and more diluted. It starts at an absolutely safe limit, and it is getting still safer all the time. And, beyond all this, I am told by our engineers that there is no engineering difficulty whatever in having sufficient gates in the dam to empty the entire basin within two feet of the bottom, or, in fact, to the bottom, in one tide; so that practically, besides this tremendous immediate dilution, which is all the time growing more, we can discharge the entire basin, and let the whole thing go out to the ocean.

In 1894, when this matter came up before, statistics were given — and they are always appalling — of the growth of population in this district, what it was to be in twenty, thirty, fifty, one hundred years, etc., from this time. It seemed to be assumed that the sewage of all this further growth of population was going into the river, but I think the facts are not at all that way. The modern system of draining is not to use the same sewers for storm water and sewage, but it is to drain the territory on the separate system. Not only does that apply to the future extension of sewers; for instance, the city engineer of Brookline stated before the commission — or at least it has been stated to me by persons of authority in Brookline — that the policy was now, when any new sewers were put in, to separate the storm water from the sewage. The city of Cambridge has adopted the same policy, and it has gone even farther, for the city of Cambridge has spent since 1894 a quarter of a million of dollars in separating the sewage and the storm water in districts where they had already been joined. So I believe the history of this district is inevitably going to be that separation is to be carried farther and farther; and there is not going to be constantly more and more, but in fact less and less, sewage finding its way through these storm overflows.

I would like to dwell for a moment on the case of Cam-

bridge, because I think it is typical of the whole subject. There was quite an important report made in 1898 by the city engineer of Cambridge, Mr. Hastings, in response to a resolve of the city council, which was as follows: "In common council, Aug. 6, 1897. *Whereas*, in the past year, the sewers in many sections of the city fail to work properly during a heavy rainfall, as a result, a large number of cellars have been flooded by the sewage backing in. This has caused an incalculable amount of injury and expense, besides being a menace to the health of the occupants of the buildings." Mr. Hastings was asked to investigate this whole subject, and at the beginning of the printed report which he submitted, giving the result of his investigation he says: "The complaints referred to in the resolve have been so numerous, and the locations of the troubles complained of are so varied, that the matter resolves itself into an examination of the whole system of the city, rather than that of any special locality."

Then he speaks of the problem in Cambridge, and says of the 3,864 acres occupied in Cambridge, 1,645 acres are less than five feet above mean high water, and he dwells on the extreme difficulty of efficiently draining that territory. Then the city engineer says that the plan which would further relieve the sewers in Cambridge which are choked is, in the streets where one sewer now exists, to build a second sewer, and then to separate the storm water and sewage by devoting one of the sewers to each, and in this way to get a separate system. He further says: "By the second plan [that is, the separate system], what is generally considered the most perfect and satisfactory method of sewerage, from a sanitary standpoint, would be adopted, which in our case would most surely prevent trouble from back water, etc., from sewers."

Then Mr. Hastings says, in his treatment of the problem, it is very important for him to consider whether the Metropolitan Sewerage Commissioners are going to require separation of storm water from sewage, — as they well may, since the Metropolitan Commission, if the combined system is in use, is put to the expense of pumping enormous quantities of storm water. It is a question whether the city of Cambridge or any other city should thus dump all its storm water onto the hands of the Metropolitan Commission, or whether the different cities should be obliged to separate their storm water, and thus save the Metropolitan Sewerage Commission the expense of pumping it.

Mr. Hastings accordingly wrote a letter to the chief en-

gineer of the Metropolitan Sewerage Commission, asking what would be the policy of the commission in regard to that. Mr. Hastings' letter said: "I am now studying plans of certain changes to be made in a sewerage system for this city, and am contemplating recommending the introduction of separate systems, taking little or no surface or rain water," and he asks what the policy of the Metropolitan Commission is going to be.

Mr. Brown, the engineer of the Metropolitan Sewerage Commission, replied to Mr. Hastings as follows: "Your note of Feb. 15, 1898, in relation to special connections with the metropolitan system for 'separate system' sewers for low areas in the city of Cambridge, was submitted to the Metropolitan Sewerage Commissioners at their meeting, Saturday, Feb. 19, 1898. They instruct me to say that they desire to favor the construction of separate systems of sewers as far as possible throughout the metropolitan area. It will extend the life of the works and reduce the cost of operation and maintenance. At some later date, when the capacity of the system is reached, it may be found necessary to require that all connections be from separate system sewers."

So Mr. Hastings says in his report that "It would seem to be the policy of the commission to encourage and favor, and possibly in the future to require, the separation of sewage from storm water in municipalities now operating a combined system of sewerage."

It is not necessary to go further into that, but I hope the committee will read that report. The city engineer of Cambridge closes by recommending the adoption of the separate system in a good many cases, to take immediate effect; and the general substance of his conclusion is that, as the city grows, the separate system must be gradually introduced.

Now, the Stony Brook problem. Twice the main Boston sewer has broken, and at one time, for example, for three entire months the entire discharge of this main sewer emptied into the Fenway. Of course that became extremely offensive. There was a deposit there, and it had to be removed. The method by which it was removed was pumping that deposit by some hydraulic process out into the Charles River, and leaving it there, in the hope or expectation that the currents or tides of the river would move it off. It was found, however, that this deposit stayed in the Charles, just where they put it, and continued to be offensive. Finally the city had to dredge that sewage out

of the Charles, picking it up and carrying it away bodily. You can see even the tidal Charles did not suffice to take care of this sewage.

The point I am making is that, even if the present Stony Brook outlet was continued and caused to empty into the Charles River, if it made a deposit, the present current of the river would not take it away. The only solution of that problem is to do for the Stony Brook just what has been done for the Charles River, or is now being done; namely, to separate the storm water and the sewage, and to send the sewage down to Moon Island, and let the storm water go, if you desire, into the Stony Brook basin. So far as I know, that problem can be given the same treatment that has been given, and is being given, to the Charles River.

At the present time it is thought best to allow the Fenway to rise and fall to a very limited extent, possibly a foot, or it may be a little more. If the river is kept at a constant level, that rise and fall in the Fenway will cease. I think at the outside the rise and fall is 2 feet.

Mr. Dunbar. I thought the level was 9 feet, and the tide was 5, at least.

Mr. Storrow. It is a very limited rise and fall, for the reason, I fancy, that it would be offensive to cover and uncover the flats. I think the rise in that basin is very limited, and the circulation there at present is not satisfactory. I find that Mr. Putnam, the assistant engineer of the Park Commission, on page 139 of this record says that the rise and fall in the Fenway is 18 inches. But of course we will cut off that 18 inches by this dam in the Charles. Now, what are we going to do? There is an old, practically disused sewer, which runs along from the head of the Fenway into Charles River along Brookline Avenue, that will be just at the foot of the Muddy Brook parkway and just at the head of the Fenway. Now, I have been told it only requires a very small lift, a matter of 2 feet or something like that, to lift water from the head of the Fenway into that old sewer. When you have lifted it into that old sewer, it runs back through the sewer into Charles River. I think that this circulation was first suggested by Mr. Stearns. So that a pump kept working at the head of the Fenway would keep a constant circulation of water in the Fenway, the difference being that the water would be kept going up the Fenway, rather than down. I have been told, and believe, that you can get a more satisfactory condition of affairs there in that way than you can by this uncertain

and unsatisfactory method practised to-day, of letting the water in the Fenway rise and fall 18 inches with the tide.

In the report from which I have just read, of the engineer of the city of Cambridge, he mentioned one present serious defect in the Cambridge sewer, and that is, the flooding due to excessive high tides. There has been very serious complaint in Cambridge, — I think we all know, as a matter of common knowledge, also, that there have been a good many houses in the Back Bay affected in the same way. Of course one advantage we would get from the dam would be that we would prevent entirely in the future these excessive high tides in the river.

Now, I want to say a few words on the question of the harbor, and I do it with a good deal of diffidence. The commission will appreciate that I am only exposing my ignorance and prejudices, and that it is for them to combat them; but I hope they will take the trouble to do it, or, assuming that I am a sample citizen, we will be asking for another commission. I first want to say that the Charles River is not a silt-bearing stream. I believe that the commission will find, when it studies this subject, that whatever silt gets into Boston harbor has not come down the river but has gone up the harbor. I think that the guilty party, if there be one, has not been the Charles. I am pretty familiar with the Charles River. I have skated down from Medway, or Medfield, I have forgotten which, away up above Dedham, in the winter, and I have canoed down from there in summer, and I know well that for miles and miles it is a very sluggish stream, with hardly any current. In the summer I live out on a hill that overlooks the great Dedham marshes. When I get out there in the spring the river is at its height, but the effect of that is not to *increase* the current, but, paradoxical as it may seem, to *diminish* the current. The reason is, that the moment there comes a freshet the river is broadened enormously, the water distributes itself over the meadows, and becomes instead of 50 or 60 yards wide, in many places a half mile or a mile wide. We all know how that is. I have skated there in the winter or have rowed a boat or paddled a canoe under those conditions, and it is like a great big pond, — you can hardly discover any current whatever when those meadows are flooded in that way. There is so little current at those times that you are not conscious of it. So that we have a condition there which cannot accumulate sediment; it is a condition of deposition. Below these meadows we have the mill pond and dam at Newton Upper Falls, and if any sediment could

ever go to that mill pond and then could pass through and out of that, there are still a number of mill ponds to catch it. The most important of these mill ponds below Newton Upper Falls is the pond created by the dam of the Boston Manufacturing Company at Waltham. Riverside is situated on the upper part of the mill pond. Here a great deal of boating is carried on. It is 9 or 10 miles from the city. I think the Metropolitan Park Commission chairman said he had taken a census of the canoes which are kept on this mill pond, and found that there were 2,500 canoes kept out there for the use of the people. Then we come to one or two more dams and mill ponds, and finally to the Watertown dam, which is the lowest, with only 4 or 5 feet of fall, I think. Then, if we are allowed to utilize this basin for park purposes, we will have one more settling basin, which will be 8 miles in length, but in which there will be nothing to settle, because nothing has come down. However, if there were anything to settle, it would settle there. If there should come a cold snap, and the commission would go to Dedham, they could skate over the Dedham marshes for a distance of 8 or 10 miles, or, in fact, except for one dam which they would have to walk around, I think at least 25 miles. It seems to me that it is amazingly absurd to seriously discuss the question of sediment coming down this sluggish, winding, meadow-girt Charles. The sediment is not there, and will not be there when the water reaches the basin; and, if there were sediment, it would be gone by the time you get the water over the dam; and, as a last and final resort, I urge that if anybody ever thought, by some minute and very delicate process of weighing, he had found what the doctors call a trace, the cost per annum to dig it out of the harbor would be so small that we are ready to bear it.

Now, about the harbor itself. I have read the report of the commission of 1835, and the long series of reports from 1859 to 1866, and there is a great deal said there about tidal prism, and the importance of the tidal prism, and the consequences that are going to happen if that tidal prism is interfered with; but history shows that for a hundred years we have done nothing but interfere with the tidal prism, and by some means, human or other, the harbor channel has not only been holding its own, but getting steadily deeper. It shows that nature, or nature plus man, has been able to cope with the conditions. This is a photograph taken from Beacon Hill in 1858, showing the Back Bay basins and mill dam. From the beginning there has been cut off in Charles River basin alone more than one and

a half times in cubic feet the amount that we propose to interfere with now. This photograph shows the present Charles River basin plotted on the Des Barres map. Des Barres was an English engineer who made a map at the time of the revolution in 1775, in connection, I suppose, with the defence of Boston. This photograph shows what an insignificant amount of prism we are now dealing with, compared with what has already been cut off. Our harbor is here to-day, and it is a good deal deeper now than it was when Des Barres made his map, in spite of the fact that all the prism outside of those lines has been cut off, and in spite of the fact that outside of these lines there is more prism that we are going to affect. It is also true, I think, if we take all the filling all around Boston in the Charles River and elsewhere, that what we are concerned with here has a value of only 15 per cent., as compared with 85 per cent. which has been already taken; 85 per cent. has been taken, and we still have a city and a harbor, and ships come up as big to-day as any that have ever come. The engineers of this country seem to have been able so cope with the loss of this 85 per cent., and I have faith that the engineers of this country will be able to cope with the loss of this last 15 per cent.

Now, the question of justifying, if I can, my statement that the source of whatever trouble we have had here with the harbor came from the mouth up and not from the river down. The committee, I think, are well aware that the islands in Boston harbor are largely composed of glacial drift. Those islands stand there at the mouth of the harbor, composed of loose gravel, clay, boulders mixed in together, many of them are drumlins or whalebacks, geological formations which the committee understand were created by the deposit of earth under the ice at the time of the last glacial period similar to the deposit, a sand bar under a river. Those drumlins were matted down hard under the ice, but under the action of waves they disintegrate very rapidly. These big drumlins stand all around our harbor, like lumps of sugar. Exposed to the waves of an easterly gale, they melt away rapidly. The government engineers appreciated this very thoroughly at the time they made these '59–'66 reports, and they went very fully into this subject. These drumlins at the mouth of the harbor are in all stages of decay. Here is a view of one down here at the outer end of the Brewster. You can see that 95 per cent. of it has gone. Here is one 50 per cent. gone, the one at Winthrop head 25 or 30 per cent. gone, and here is one on Long

Island which has disintegrated very much. The government engineers say in the reports that in one place alone an area has been washed away equal to the entire size of Boston Common, and 66 feet deep; and that is only one case out of many. Undoubtedly the total amount of gravel, sand and clay that has been washed away from those islands is enormous. Therefore I say that the poor old innocent Charles River has been made to bear a great deal of odium which it did not deserve. Here is a photograph showing the exact texture of one of those drumlins. It can be seen that under the action of an easterly gale, with the waves beating against the exposed headlands in the harbor, this boulder clay would be eaten into with great rapidity. Here also is a perfect drumlin, showing what the outer Brewster, now 95 per cent. gone, was once like.

Now, the government engineers in that series of reports recommend that those drumlins should be protected by walls, and their advice was followed. Retaining walls have been built in all places where these hills and banks are seriously exposed to wave action, and in that way they are protected. Here are some more drumlins, in plain view. Here is a drumlin at Long Island head. This is supposed to be the original contour. Of course the waves will not work down more than a certain depth; I think the action of ordinary waves is only 6 feet. This picture shows the drumlin plateau, marking roughly the original contour of the drumlin. Here is one at Long Island, and here is another at Winthrop head, and here is one at Point Allerton. Professor Niles was kind enough to lend us these diagrams. Here is a perfect drumlin, in plain view. I don't know where that is located, but somewhere around Boston.

Government engineers state unqualifiedly that wherever a retaining wall has been built, that sort of wear has been arrested. You can easily see that that would be so; for you can put your wall anywhere you want on the old drumlin plateau, and there is no reason why a proper wall should not arrest absolutely further waste of material. As a matter of fact, government engineers say in their report, — a passage to which I should like to call your attention later, — that it is a fact that wherever those walls have been built it has entirely arrested the decay of those slopes, and grass has begun to grow upon them. If any of those places are left, that same treatment can be given to them, and should be given to them, whether we have a dam or not; so that it seems to me that when we realize that we are dealing only with 15 per cent. of a prism, 85 per cent. of which is already

gone, and when we consider that the sole substantial source of the supply of the material has been or can be readily stopped, it is not too much to say that human ingenuity and human engineers can still keep a channel open to our ships to come to our wharves here in Boston, and that at not great expense.

There is one other feature I would like to speak of, and that is, the rolling sand theory which is mentioned in the government report. The government engineers say that a Frenchman named DuBuat found that a current of three tenths of a mile per hour would roll a grain of sand. I never read his work, and I don't know much about it, and it has never been quite clear to me just exactly how he worked that out, — whether he meant a grain of sand rolling on a smooth surface, or what.

The CHAIRMAN. DuBuat explains in his own work.

Mr. STORROW. Undoubtedly he explains it in his work, which I never had the good fortune to read. The government engineers say that this back water — I am not speaking of the tidal prism — comes down the Charles River and the Mystic River, and reinforces the ebb; and, whereas the current of the river alone would not be sufficient to roll that sand along the bottom, yet it may be sufficient if reinforced by the ebb. And furthermore, the theory is that if you move a grain of sand a little way outward on the ebb tide, the incoming tide will move it just the same distance back again to just the same point where it started from, and one grain of sand will never get out to the mouth of the harbor. When the tide is reinforced by the fresh back water, however, you can add, for example, one-tenth of a mile an hour to the natural ebb and subtract one-tenth from the natural flood, and you will get then, we will say, four-tenths of a mile of flood and six-tenths of a mile of ebb, so that one grain of sand will make some progress towards the sea. That they speak of as apparently of great importance. I judge it is of great importance under certain conditions; but it seems to me, from studying the conditions here in Boston harbor, that it is not here of great importance. A grain of sand, we will suppose, starts between Boston and East Boston and makes its seaward journey and its shorter landward journey each tide, and works its way thus painfully on towards the mouth of the harbor. Then finally it gets rolled down to a point here just off South Boston which is called the upper middle. There it meets a curious condition of affairs, — and this is on the authority of the government reports; one grain of sand gets to that point, but

curiously enough, instead of the ebb at the upper middle being preponderant over the flood, the flood, for certain reasons, has become preponderant over the ebb. Now, we have rolled that grain of sand painfully down, all the way, on the bottom until we strike the upper middle, and there it must stop. There, on the authority of the government engineers, the flood is stronger than the ebb. I am speaking now of the main channel, and they mention this preponderance of the flood, owing to the position and configuration of the islands, many times in the reports. One instance of it is on page 76 of the final report for 1866 where they say: "Boston upper harbor presents, as one of its worst features, a flood predominance in a portion of the main channel, — that portion which lies between Bird Island and South Boston flats. The upper middle bar upon the one hand, and the anchorage shoal upon the other, are the limit of this flood channel. These two banks are, in fact, the debatable districts where the flood and ebb are equal in power." And so on. They state the exact difference to be fifty-two one hundredths of a mile for the ebb and for the flood sixty-three one hundredths of a mile. There we ought to convict the Charles River, if we can convict it anywhere. Up to this point the sand has been rolled for thousands of years, but it can go no further, and here we ought to find it in a great heap, blocking the channel. As a matter of fact, we do not find any heap of rolling sand here at all. It is not there. There is a shoal there, it is true, but this shoal is not composed of rolling sand. The commissioners say: "The upper middle is not an accumulation, but a ridge of the original blue clay which underlies the neighborhood of Boston. It has not been removed, because the currents have not had adequate power." They further say: "In a future report we shall show that the upper middle would have long ago been removed by the scour of the current (for it is a bed of brick clay), had it not been for the dispersion of the scouring portion to which we have referred." It seems to me, therefore, that, so far as the rolling sand theory is concerned, its applicability to Boston harbor is at least removed from the ground of substantial commercial importance by the fact that right at that point we have the predominance of the flood over the ebb, and at several other points we have the same thing. Down through the Narrows we have no ebb at all, or cross current, and I think that at one other point at least we have a predominance of the flood over the ebb.

I think in a hasty way I have covered the subject as

it appears to an average citizen, and the commission, I hope, when it makes its report, will make it in such a way that we will either be persuaded that we can utilize this Charles River basin for the dignity and beauty of our city and the health and enjoyment of all our citizens, or else that for some cogent and unfortunate reason we must forego this apparent opportunity, and continue to turn our backs on it. I personally believe it to be absolutely true that this commission cannot find that it is *impossible* to turn this basin into a water park. I believe that this commission will find itself absolutely unable to establish the proposition that it is *impossible* to build this dam. It seems to me that this commission will be utterly unable to find a single objection to the proposed utilization of this basin which cannot be avoided at the outset or met by some engineering plan or contrivances, or counterbalanced by the annual expenditure of some sum of money, be it large or small. I do not believe the commission can find it impossible to build the dam, because I believe it is simply a question of engineering skill, first to construct the dam, and then to provide for or obviate any defect or disadvantage that may ensue from the dam. If sediment should settle in the harbor channel, for instance, we can dig it out; if there is trouble with any sewerage, that can be taken out of the basin. The Binney Street sewer, for instance, can easily be extended below the site of the dam. In like manner sewage can be kept out of Stony Brook by separating the storm water, or Stony Brook conduit can be extended below the dam. There is not one single objection that has ever been made to this project which involves more than a certain number of dollars and cents to obviate it.

I say respectfully that this committee is not competent to tell the city of Boston and the city of Cambridge what they can afford to spend on this park. The committee does not know, and it has no way of finding out that. The city of Boston itself does not know this year what sum it may vote for a park next year. It is chiefly a question of how many citizens want it, and how much they want it. It also depends partly on what money is spent on other things. This committee cannot settle the financial policy of Boston or Cambridge. Furthermore, if the committee thought it was competent to lay down what the city of Boston, or the city of Cambridge, or this metropolitan district, or the State of Massachusetts, — because the State might take up this project, — if the committee thought it was competent to settle such a financial question to-day, yet how can this

committee tell what these cities, or this district, or the State, can spend to-morrow? Population is increasing, wealth is increasing, the cost of engineering work is decreasing; what might not be feasible to-day may well be five years from to-day. In reading one of these government reports, which is published in the same volume as the city documents, I read a municipal ordinance passed by the city fathers in 1865 or 1866, to the effect that the horse-car companies after a snowfall should not remove the snow from their tracks, but should cease operating their cars, and take people through the streets on sleighs or runners. Anybody here who is fifty years old can probably remember the time when that ordinance was in effect. Now, that was probably good engineering at that time. The traffic at that time did not warrant anything else. Neither the horse railroads nor the city could afford to pick the snow up and carry it off; so, to prevent the snow being simply heaped up on the sides of the streets, the railroads were ordered to abandon their tracks and take people round on runners. There was not any engineering difficulty about carting the snow off when that ordinance was in force, but the traffic in the streets and on the street cars simply did not warrant the expense. That ordinance was accepted as good sense for that time, but the growth of population has made that method obsolete. It is not because of any change in engineering, because snow could be shovelled up and carted off then. It is a mere question of what the community can afford. I read that after the snow storm this last week in New York the street cleaning department shovelled up and carted away 75,000 loads of snow in one day. Those are two extremes, and they indicate how things change. So I say that this committee should find, in the first place, whether it is *possible* to build a dam across the river; and, in the second place, what the objections are, winnow them out, find out which ones are whimsical or made because a few people really want to appropriate that basin, and what ones are really soundly public objections, and then tell us what is the cost of meeting or removing those objections. There is not one of them that cannot be removed. Digging silt out of a channel hardly needs an engineer; all we have to do is to go to a contractor. In fact, nothing in this matter in any way really presents a difficult *engineering* problem. It is merely a question of doing certain things if they are worth doing at a certain cost; and this committee is not competent to say what the city of Boston, or the city of Cambridge, or the metropolitan district, or the State of

Massachusetts can afford to spend to-day; and much less is this committee competent to say what they can afford or will choose (for I suppose it is their right to be even extravagant, if they want to), to spend three years of five years from now. We would like to know what the sum involved in this improvement is. Perhaps we cannot stand the cost; we hope we can. But, whatever it is, tell us, make your mark, and, if we cannot reach it now, we will get to it by and by. I thank you, Mr. Chairman and gentlemen of the committee.

The CHAIRMAN. The committee will now adjourn until 10 o'clock to-morrow morning, Friday, Feb. 28, 1902.

SEVENTH HEARING.

RAILROAD COMMISSIONERS' OFFICE,
BEACON STREET, Feb. 28, 1902.

The hearing began at 10 A.M., all members of the committee present.

Mr. STORROW. Mr. Chairman and gentlemen, with your indulgence, I would like to say just a few words, not to occupy more than ten minutes of your time this morning, and then Mr. Blake, one of the engineers retained by those in favor of constructing the dam, will, I suppose, occupy the rest of the day putting in his testimony.

I spoke yesterday of the Charles River, and pointed out the impossibility of any substantial sediment of silt coming from that source. I also spoke of the islands in the harbor and the way in which they had worn, the engineers composing the commission of 1859 saying that in some places the islands were wearing at the rate of 2 feet a year; also many hundreds of acres at least have been worn from those islands; and I also pointed out, on the authority of the commission of 1859, that further wasting of these islands and headlands had been absolutely stopped by protecting walls wherever these walls had been built.

In the case presented before the Harbor and Land Commissioners by those opposed to the utilization of Charles River basin as a water park, one other alleged danger to the harbor was urged, and that was, the washings from the city streets. It was said that whenever a heavy storm came a certain amount of dirt would be washed from the city streets into the settling basins, and, though no doubt most or much of it would be retained there, yet a certain proportion of it would find its way into the harbor. I do not know that any attempt has been made to estimate just what that is. In the first place, I think the committee will find that the annual cost of removing from the harbor such proportion of the sediment as gets into the channel from this source will be a small matter, measured in dollars and cents. In the next place, the city streets are now cleaned, as we all know, by certain gentlemen who somewhat leisurely use a broom and draw $2 a day, and by other gentle-

men who rather leisurely wield a shovel and also draw $2 a day, assisted by another citizen who manages a cart and a horse, at an expense to the city, I suppose, of at least $4 a day. Of course this is an enormously expensive method of picking up and carrying off sediment or dirt deposited in the city streets. Now, it has been pointed out by the opponents of this plan, as if it were a very terrible thing, that in the case of a heavy shower this street sediment is washed from the city streets, and a certain percentage of it escapes into the harbor, and that a certain percentage of this percentage may get lodged in the channel, where in the course of time it will have to be dredged out. Now, I do not look upon this as such a frightful thing, after all. In fact, I believe it would be a good thing for the city of Boston if we could have a rain every night that would wash the whole of the street sediment right into the catch-basin, even if some small percentage of it had to be dredged out of the harbor. It has been estimated roughly that it costs about $1 per cubic yard to get the sediment out of the catch-basins. What it costs to sweep it up and take it out of the streets I do not know, but I fancy it is a good deal over the dollar mark. Now, suppose some of that street dirt is carried into the harbor; the cost of removing it from the harbor will be only about 17 cents a cubic yard, as compared with from six to ten times this rate per cubic yard which it costs to take it from the streets. This does not seem to me to be such a frightful thing, after all. Furthermore, I do not suppose the most rabid opponent of this project would urge that more than 10 per cent. of whatever street wash may get into the harbor will find its way into the channel. The channel certainly does not represent more than 10 per cent. of the superficial area of the harbor. So we can divide the 17 cents by 10, and we get a cost of 1.7 cents, — the cost of handling it when nature does not assist, in case a cubic yard of street wash goes into the harbor, as compared with a dollar or a dollar and a half if it has to be removed directly from the streets by the shovel and broom brigade. Now, I think we have touched on all the possible sources of sediment. We think there cannot be any sediment in the harbor unless there is some place for it to come from; and we invite those opposing the utilization of this basin to point out any source besides the islands, which are now protected, and the street washings, which cannot involve any very serious annual charge in the first place, and which ought to

be welcomed in any event as constituting on the whole the cheapest method of disposing of it.

Besides the fact which I pointed out yesterday, that, owing to the configuration of the channel, the resultant flow in the channel at the upper middle is *up* and not *down*, there is one other significant fact about the harbor channel, and that is, that the bed of the channel does not slope as an inclined plane gradually towards the sea, but at certain points there exist deep pockets in the channel, — holes that have been in the channel from the earliest measurements, more than a hundred years ago. Now, if there is sand moving along the bottom of the channel, how about those pockets? Of course the current here becomes an eddy, or at least slacks. It is not necessary to suppose that it stops, but the least slacking will cause a deposit of the larger grains which the swifter current was just able to roll to this point. Why have those pockets not been filled up? That is a question which we would like to have answered. Our engineers will point out to you the location of those pockets, when it comes to their evidence.

When this matter was discussed before the Harbor and Land Commission, there were pages and pages of testimony on the subject of malaria. Several experts were retained in 1894, by those opposed to the utilization of Charles River basin, to work the malaria objection. They admitted very frankly at that time that very little was known about malaria or its causes; but that only made their argument the stronger, because, not understanding its causes, we could not tell what change might produce it, and therefore it was very important to do nothing. Fortunately, since 1893 and 1894, the scientific men have made a great deal of progress in their study of malaria, and the means by which it can be communicated. I think the medical profession to-day is practically a unit in the belief that the only way in which malaria can be communicated to a human being is by the aid of a certain mosquito with a Latin name, — not the common, ordinary mosquito, fortunately for us, but the genus *Anopheles*, which, fortunately, is not common around here, but which is especially common in places like the Roman Campagna, for instance. The scientific men have discovered that there is no danger from a wind-swept open basin, such as is proposed here, with a chance for the wind to get at it and with little waves to ripple across its surface, because the *Anopheles* cannot, under such conditions, breed. Besides, nowadays the birth

of these mosquitoes can be easily controlled, as may be learned by reading the government reports that General Wood is sending up from Havana. Down there they have been fighting yellow fever on the theory that its chief means of conveyance is the mosquito, and during the last year they have made a most extraordinary record in Havana for the prevention of yellow fever. I believe months have gone by, in the height of the yellow fever season, when deaths used to be numbered by the hundreds, with no deaths at all; and they attribute their success entirely to the effective manner in which they have gone all around the city, treating standing or stagnant water with oil or other agents which prevent the breeding of these mosquitoes. At the very worst, a minute film of oil, which would not be noticeable, could be placed on the surface of this basin, and it would absolutely prevent the possibility of the breeding of the genus *Anopheles*. There is not the slightest danger, I believe, of mosquitoes breeding in a large basin of water with clean shores, where the air gets at it, but only from stagnant water, or such pools as are left by an unusually high tide, and then stagnate.

Among the names of those advocating the improvement of the basin I believe there are now over three hundred members of the medical profession living on the Back Bay. We rather chose members of the medical profession living on the Back Bay, because we felt that, living there, they had something at stake; and it is, I think, practically the unanimous opinion among the medical profession to-day that there is no danger from this proposed water park, so far as malaria is concerned.

Mr. DUNBAR. Those names are the names of those you have got asking that this matter should be investigated, or saying that this improvement ought to be carried out?

Mr. STORROW. I should perhaps have stated that. I don't know that a good many of those physicians have committed themselves beyond the point that they felt faith enough in the proposition to have a commission investigate the subject of the building of a dam.

Mr. DUNBAR. Are they in favor of the investigation of the subject, and not in favor of the carrying out of the improvements?

Mr. STORROW. So far as I am aware, most of them are in favor of carrying out the improvements. I have had many letters, and you will find many letters among the hundreds that we have filed with the committee, which

state that, in their opinion, they not only believe there is no objection to this proposed water park on the score of health, but that, so far as public health is concerned, the basin would, in their opinion, be a great benefit. There are some of the doctors who did not go further than to intimate favoring the proposition to have the matter investigated. I would like to quote here the statement made by Dr. Richard C. Cabot, who is an authority on the subject, at the time this matter was up before the legislative committee last spring, as follows: —

It is now generally believed by physicians and biologists who have devoted study to the subject that malaria is transmitted to man solely through the bites of mosquitoes. Experimentally, malaria has been produced in perfectly healthy persons by exposing them to the bites of mosquitoes previously fed on the blood of persons infected with malaria, the type of disease so produced being always identical with that of the original case.

The malarial parasite has been demonstrated in the stomach wall and salivary glands of mosquitoes after they have bitten persons suffering from malaria.

Persons adequately protected against the bites of mosquitoes do not contract the disease. Two Englishmen passed the summer of 1900 in the most malarious part of the Roman Campagna, exposing themselves constantly to the damp night air, drinking water from springs in the vicinity, and endeavoring in every way to do what was popularly supposed to be most likely to produce malaria. The only precaution which they took was to protect themselves assiduously against mosquitoes. No sign of malaria showed itself in either of them, although many of the inhabitants of the houses close by were shaking with the disease at intervals throughout the summer.

Luckily for us, not all varieties of mosquitoes are capable of transmitting the malarial parasite to man. The members of the genus *Anopheles*, which is (so far as is known) the only genus to be feared in this respect, are not nearly so ubiquitous as the ordinary house mosquito (genus *Culex*). Whereas the latter has innumerable breeding-places under divers conditions, the malarial mosquito breeds only in stagnant, shallow pools; in deep or ruffled water it does not propagate. There is no evidence for believing that we can increase the amount of malaria in any locality by any changes that do not favor the production of small, shallow, stagnant pools. Ponds or lakes of fresh water do not tend to produce malaria unless their banks are shelving and overgrown with underbrush, so that the water can stagnate, unaffected by wind and waves, and so offer quiet breeding-places for the *Anopheles*.

Now, a word about the Harbor and Land Commissioners' report in 1894. Unfortunately, the Harbor and Land Commissioners had no means placed at their disposal for making any independent investigations. I believe that the appropriation was only $1,500, and I think the commission speaks of it as being only sufficient to pay the stenographic,

printing and other expenses of the commission, leaving not a dollar which could be used by them for making any independent investigation, or consulting an independent expert. Such being the case, the Harbor and Land Commissioners were obliged to consider simply such evidence as was brought before them. They could not, and the record shows they did not, get a particle of evidence themselves. Now, what was brought before them? Certain people living on the water side of Beacon Street took sufficient interest in the matter to retain very eminent and astute counsel, the two ex-governors, Governor Russell and Governor Long. They also retained a number of experts, for the purpose of killing what we believe to be the proper and only satisfactory treatment of that basin. The committee retained Prof. Dwight Porter and Col. George E. Waring of New York, and a very large and substantial sum of money was raised at that time or put in the hands of the committee to oppose the project. So far as I am aware, no sum of money was raised, substantial or insubstantial, to bring out the evidence in favor of improving the basin of Charles River; therefore, since the Harbor and Land Commission itself had no funds to make any independent investigation, and a large sum was raised to produce evidence against this method of improvement, and not a dollar was spent either for an impartial investigation or to bring out what would be said in favor of the project, I think it is not too much to say that the Harbor and Land Commissioners were obliged to decide the question upon an *ex parte* record. It is true that Mr. Stearns was asked by the commission to state his views, and he did so; and it is also true that the city solicitors of Cambridge, Newton and Watertown did good service, considering that they had no means placed at their disposal for presenting the case in favor of utilizing the Charles River basin; but I think nobody can read the record before the Harbor and Land Commissioners without feeling that the case was presented in a one-sided, *ex parte* manner. That is one of the reasons, and a sufficient one, why we have not been satisfied with the Harbor and Land Commissioners' report.

Another reason why we have never been satisfied with that report is, that the commissioners themselves apparently were not satisfied that the evidence on both sides of the case had been brought before them, for they sum up their conclusion at the end of their opinion as follows: "This Board is powerless to say, on the imperfect information it

has, what effect a dam as proposed would have on shoaling in the upper harbor" (record of 1894, p. 19).

It is not surprising that the commission reached that conclusion, in view of the fact that they had no opportunity to make an investigation themselves, and in view of the fact that there was nobody willing to place, against the fund that was raised to fight the investigation of this basin, a corresponding sum to bring out the facts and evidence in favor of the utilization of the basin. At the present time, fortunately, this committee is better situated in these respects. The commission itself will be able, owing to the larger appropriation placed at its disposal, to consult independent experts on its own behalf. Furthermore, certain citizens have taken sufficient interest in this water park to say that they are willing to bear the expense of bringing out the evidence in favor of the dam; and this commission is also fortunate in having certain citizens here who are ready to bring out what can be said against the project; so that this committee is going to have this matter brought fairly and fully before it, and there will exist no reason why anybody hereafter should say that the conclusion of this committee was based upon one-sided or *ex parte* evidence, either for or against the project.

It is also true, of course, that since the 1894 report a great many changes have taken place. I stated yesterday that the municipalities, cities and towns, and Metropolitan Park Commission, had already spent three million dollars on the theory that the Charles River was going to be used for pleasure purposes, and I think fairly committed themselves to the expenditure of at least two millions more along the same line. I think this five million dollars is practically to be expended on the Charles River on the theory that the river is to be utilized as a part of our park system.

As to the attitude of Boston and Cambridge on the question, the very existence of this committee and the fact that it was not compulsory, but its expenses were voluntarily accepted after the recommendation of their respective mayors by the unanimous vote of their legislative branches, show where Boston and Cambridge stand. The cities of Newton and Watertown have also always shown a deep interest in this project; that is evident from the fact that, when this matter came up before, the city solicitor of each of those towns was present, with the city solicitor of Cambridge, and assisted in favor of improving the basin. I believe the city solicitors of both Newton and Watertown have again been

instructed by their towns to aid in presenting the case in favor of utilizing the basin, on the general lines proposed by the petitioners here. Boston, I am also told, has also passed unanimously, through its city government, a fresh resolution within the last few weeks, in favor of utilizing this basin as a water park. A resolution to the same effect was also passed last year.

Just one other thing. I said yesterday that this subject had been agitated for thirty-three years; I think I can add one year more to that now. Here is a plan very similar to the one we are now urging, which I understand was advocated before the Legislature of Massachusetts in 1868. This lithograph is a reproduction of the plan advocated in 1868. I said to the committee yesterday that in 1879 Mr. Uriel H. Crocker wrote a letter to the Boston "Advertiser," advocating the improvement of the Charles River basin by the construction of a dam at the foot of the basin. In 1870 or in 1871, I think it was, the Legislature passed an act for the construction of the dam at or near the site of Craigie bridge. It was provided in that act, I believe, that it should not go into effect unless approved by two-thirds of the citizens of Boston. That was in 1871. The project was not then very fully understood, and it was fought on sectional lines, and quite vigorously, because it was said that the plan was simply for the benefit of people living on the Back Bay and in Brookline, and that people in South Boston, East Boston and other sections of the city would receive no benefit from it; and the voters from these sections were urged to vote against it because there was nothing in it for them, and it was simply for the benefit of people owning land on the Back Bay or living in Brookline. I think people now look at this park in a broader way, and see that it is for the advantage of this entire community. Yet, in spite of all the opposition to the plan, a clear majority of all the citizens of Boston voted in favor of this plan as far back as 1871; and I believe there has never been a time since when a majority of the citizens of Boston would not have voted in favor of the construction of the dam and the utilization of the basin as a water park. The measure at that time failed, however, to get the requisite two-thirds, and so, though discussed and advocated, lay dormant for some time. In 1891 or 1892 the mayor of Boston, Mr. Nathan Matthews, Jr., one of the ablest and best mayors we ever had, in his inaugural address called attention to the foolish and short-sighted way in which we were neglecting

that basin. This brought the subject up again for active consideration, and led to the appointment and report of the Joint Board, composed of the Metropolitan Park Commissioners and State Board of Health. This joint commission was, I think, in pursuance of an act or resolution of the Legislature. As soon as this joint report came out, there came up the very vigorous and astute opposition of certain of our citizens living on the water side of Beacon Street. These gentlemen succeeded in getting the matter referred to the Harbor and Land Commissioners, and before that commission they succeeded in killing the project by getting the Harbor and Land Commissioners to find that they were "powerless to say . . . what effect . . . a dam would have." This is the history of this thing, I think, from the beginning.

Colonel MANSFIELD. What is the history in regard to the construction of the dam at St. Mary's Street?

Mr. STORROW. As a result of the agitation in 1893 and 1894, an act was passed by the Legislature, directing the Metropolitan Park Commissioners to prepare plans for the construction of a dam across the Charles River basin at or near St. Mary's Street, — this point here at the head of the basin, instead of at the foot of the basin, — to my mind, an absurd proposition. Nothing has ever been done under that act. One of the necessary steps to the construction of any dam at any place across this river is the consent of the United States government. That consent has never been applied for, I understand. In fact, I understand no plans have been prepared and nothing has been done under that act. I will say that I personally remember going once before the Metropolitan Park Commission and urging them, if it was possible in any way to delay the matter, to do so, and not to build a dam at the head of the basin, as I considered it most foolish and unwise. Personally, I would vastly prefer to have no dam whatever at the present time rather than to have one constructed at St. Mary's Street. I would rather put this whole thing off twenty-five years, and get it then, rather than do that which I believe would be worse than a waste of money, and which would not only fail to bring about the use of the basin, but would very much interfere with what little use there is now made of it. I thank the committee very much.

TESTIMONY OF PERCY M. BLAKE.

Mr. MATTHEWS. Mr. Blake, before you proceed with the reading of your paper, will you please give a statement of your name, residence and professional training and experience?

Mr. BLAKE. My name is Percy M. Blake; I am a resident of Newton; I am a civil engineer by profession, and have been engaged in civil engineering since 1869. From 1871 to 1875 I was engaged by the United States government on river and harbor work in the department of which Gen. G. K. Warren was the engineer in charge. Since 1875 I have devoted my time almost wholly to hydraulic work and sanitary engineering. In the course of my experience I have had to do with problems of river and harbor improvement, as an assistant engineer; with the measurement of water in rivers; the gauging of stream flows, large and small; sewerage problems of nearly every kind, and ground water problems, such as come up in the matter of draining grounds, the obtaining of ground water supplies for public use and the attendant details which are required in investigating ground waters. My studies in the territory which may be remotely connected with this case were investigations and surveys involved in the proposal to discharge sewage at Nut Island. That study was made in 1889, for the city of Quincy. Nut Island is a point shown on many of the maps already on file. It is on the northerly side of Hingham Bay, and is the point at which is to be discharged the sewage collected by the new high-level metropolitan sewer, now in process of construction.

Mr. MATTHEWS. How much time have you spent on this case?

Mr. BLAKE. Nearly all the time for the past three months.

Mr. MATTHEWS. I believe you have read and considered the literature which has been accumulated on this question.

Mr. BLAKE. I have, sir. I began with the voluminous report of 1894 on the proposed dam, as printed by the commission of that year, — the Harbor and Land Commission.

Mr. MATTHEWS. Have you read or heard the statements made in this case by the various public officers?

Mr. BLAKE. I have not attended all of the hearings, but I have read everything that has come before this committee which the time would allow me to read.

For convenience, I have prepared the result of my studies in the form of a report, made as brief as possible; a large map; and a blue-print, showing details suggested for the proposed dam. I wish to say that in the preparation of the map I have shown nothing more than appears to come

into the case. You will accordingly notice, if you examine this map, many omissions, especially if you compare it with some other maps which have been presented. The map shows at its western end Newton Upper Falls and that portion of the Charles River which contains the dams. Above this portion lie the very extensive meadows, many square miles in area, which serve as a reservoir and regulate the flow of water in the stream. Above the Newton pumping station the regimen of the river is affected by the large reservoir areas. This map is drawn on a scale of 800 feet per inch. Parks and public reservations are shown in green tint. The areas filled in and to be filled to official lines, which will ultimately make the outlines of Boston, are shown in pink. For instance, "old Boston," as it is lettered on the map, is that portion of hard land above high-water mark existing when Boston was first settled. The original South Boston is shown in the same way, marked "South Boston," and shown in plain white. The pink areas outside of that territory and within the heavy blue lines are areas which are filled or being filled, and the blue lines on this map marked "harbor lines" are the official lines which have been laid down by the United States government authorities, and out to which it will not only be permissible, but advisable, to fill, in the development of Boston as a port and a maritime city.

I will not take any more time to describe any other details, as I trust they will appear plain in themselves. I will simply call attention to the proposed 35 foot harbor channel, which is to be authorized and dredged by the general government. It begins at Mystic wharf and Chelsea Creek on the north, the outlet of Charles River on the west, and extends within the lines shaded drab through the President Roads and Broad Sound to the sea. The darker portion of the path represents the portion which will require dredging in order to secure a uniform depth of 35 feet. The portion with the lighter tinting is the basin of President Roads, some of the depths in that basin being 47, 58, 60 and 65 feet.

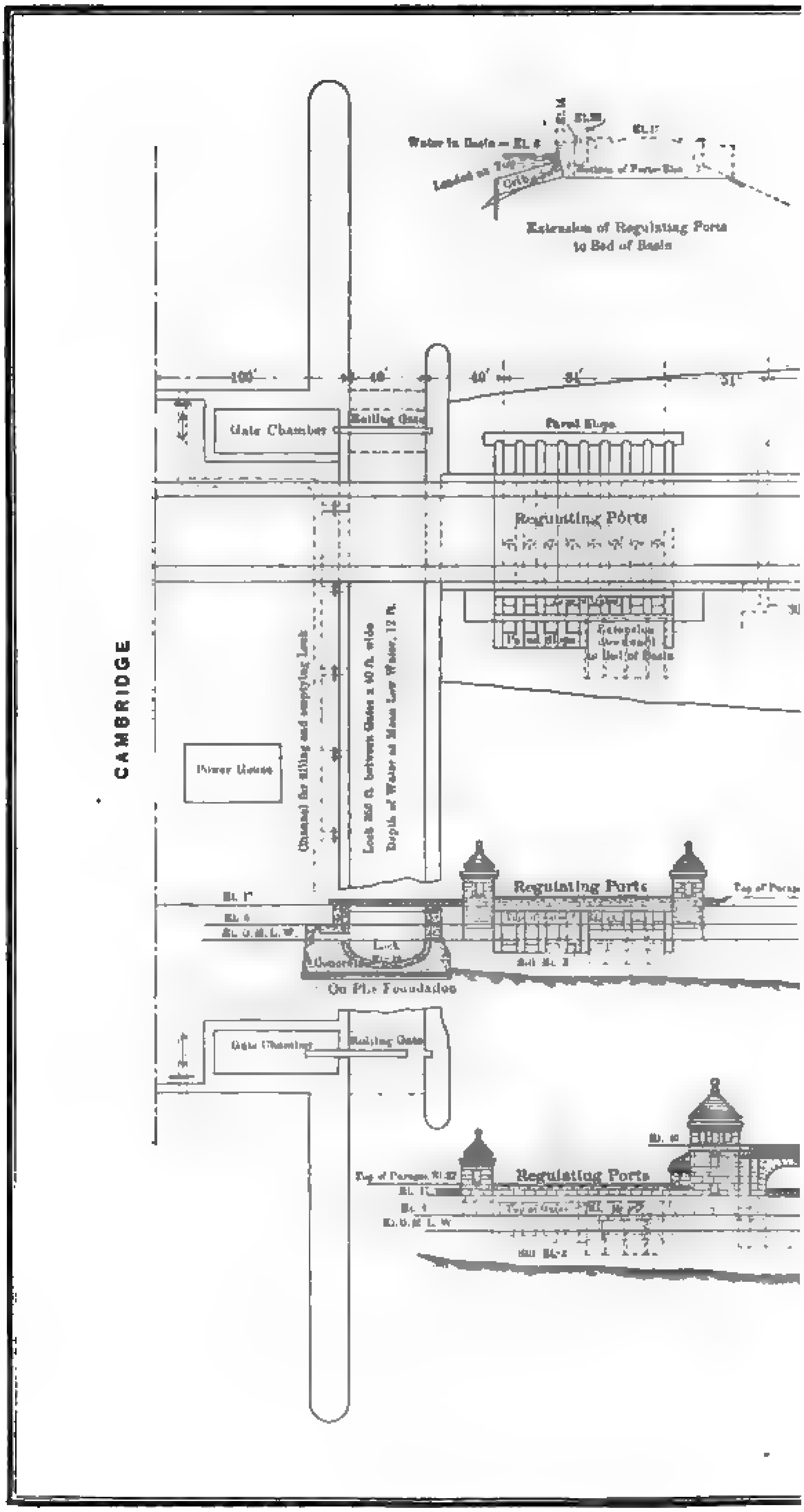
Mr. Blake then submitted the following report: —

To HENRY L. HIGGINSON, AUGUSTUS HEMENWAY, JAMES J. STORROW AND OTHERS.

GENTLEMEN: — I respectfully submit the following report on the proposed Charles River basin, and accompanying map.

THE PROPOSITION.

It is proposed to convert the Charles River basin into a fresh-water basin, by the construction of a dam across the river at some point below West Boston bridge. If this dam is constructed just below West



Extension of Regulating Ports
to Bed of Basin
Gate Chamber
Rolling Gate
Regulating Ports
CAMBRIDGE
Power House
Lock
On Pile Foundation
Gate Chamber
Rolling Gate
Regulating Ports
Regulating Ports

Boston bridge (point A on map), the total length of the structure over all will be about 2,100 feet; if 650 feet above Craigie bridge (point B on map), the point selected by the Joint Commission in 1894, 1,166 feet; if constructed at the present Craigie bridge location (point C on map), about 1,270 feet. With an allowance in each case for a descent of the filling to a hard bottom 4 feet below the present bottom, the structures, in bulk, will require for the upper or West Boston bridge location 188,553 cubic yards; for the location selected by the Joint Commission, 169,652 cubic yards, in each case the top width of the structure to be 60 feet; if at the Craigie bridge location (to take the place of the present bridge), 368,296 cubic yards, the top width in this case to be 120 feet. The proposed dam (see plans) is to be a solid embankment with stone retaining walls resting on foundations below the low-water level, on either side. The surface of the roadway forming the top of the dam is to be constructed at elevation 17, and the shore ends of the dam are to be designed to connect harmoniously with the permanent shore lines of the river banks at either end of the dam. For the two upper locations the roadway is to be provided on either side with walks 10 feet wide, and its middle space may very properly be devoted to bicycles, automobiles and carriages. For the lower, Craigie bridge location a central space 24 feet wide is to be reserved for two tracks, and sidewalks 10 feet wide are to be provided on each side, leaving two roadways of a width of 38 feet each on either side of the two tracks.

The dam in either location is to contain a lock 400 feet in length by 40 feet clear width, with a middle depth of 12 feet below mean low water. This lock is to be operated by quick-moving, rolling gates actuated by electric motors or steam power and is to be filled and emptied quickly through side ports in one of the masonry walls of the lock. The time of passage through this lock will be less than twenty minutes. The water way through this lock with both gates open will have a section of 420 square feet at mean low water.

It is proposed to maintain the water level in the river basin above the dam at elevation 8, or 8 feet above mean low water in the harbor, and with the water at this elevation the water way through the lock will have a depth of 20 feet. With the harbor tide at mean low water the area of free discharge through the lock for the water standing at elevation 8 in the basin will be 320 square feet.

In addition to this lockway through the dam there will be eight water ways or ports, each 17 feet high by 6 feet effective width, the bottom of each port to be constructed at the elevation of 3 feet below mean low water, each port to be provided with a balanced positive gate and protected at its outer or harbor end with a tide gate so designed in connection with its own seat or frame that it may be easily hoisted or raised for making repairs. With the harbor tide at mean low water and the water in the basin standing at elevation 8 the discharging area of these eight ports will be 528 square feet ($11 \times 6 = 66 \times 8 = 528$).

Four of these ports are to have their inlets or entrances extended downward on the basin slope of the dam to a point near the bottom of the basin for the purpose of drawing off the lower water, should the same become necessary. Through these four ports may also be introduced into the lower depths of the basin such quantities of salt water as it may be desired to add to restore or maintain the water level in the basin without transfusion of salt water with the fresh water. The greater specific gravity of the sea water, 1,029 — (64.312 pounds per cubic foot) over fresh water, 997.7 — 62° F. (62.355 pounds per

cubic foot), ratio 103 : 100, will create a static condition in which this fresh water will maintain its position as a top layer in the basin.

I wish to make that detail clear, as it appears to me to be an important one. The blue-print contains, in the upper left-hand corner, a section showing an extension downward into the basin of these four ports. In effect the arrangement is like that of a suction pipe dropped down into the basin. The superior height of water in the basin when the tide is low will force the bottom contents of the basin up through these extended ports; the top water will simply settle. Such process will retain the fresh water in the upper part of the basin and the salt water will simply be forced out. By reversing that process, tidal water may be delivered into the bottom of the basin. The fresh water will simply rise as it is replaced by the salt water, and the difference in specific gravity will maintain the line of demarcation between the two waters.

Q. (by Mr. MATTHEWS). What do you call that particular attachment, — what is the name of that particular attachment? A. On the blue-print this arrangement is called the "extension downward to bed of basin."

The dam is also to be provided with an overfall wasteway with a clear length of water way of 100 feet with sill over which the water will flow fixed at elevation 5, thus giving a relief area for the flow of freshet water, the passage of floating ice and débris. This wasteway when not in use is to be closed by five sluices or gates of special design.

With the water in the basin standing at elevation 8 and the harbor tide at elevation 5, the discharging area of this wasteway will be 300 square feet; adding the area of the ports, 528 square feet, the area for the flow of water with the lock closed will be 828 square feet; adding the water way of the lock, 320 square feet, we have a total of 1,148 square feet of water way through the dam between levels of mean low water and elevation 8. With a velocity averaging 2 feet per second on these areas the discharge of water through the dam would be 2,296 cubic feet per second, or about 198,000,000 cubic feet per twenty-four hours; with an average velocity of 3 feet per second, the discharge of water through the dam would be 3,444 cubic feet per second, or about 298,000,000 cubic feet per twenty-four hours; with an average velocity of 5 feet per second, the discharge of water through the dam would be 5,740 cubic feet per second, or about 496,000,000 cubic feet per twenty-four hours.

Q. (by Mr. MATTHEWS). That is exclusive of the tidal sluices? A. Yes.

It is proposed to provide, also, special, large sluiceways through which water may be very rapidly released from the basin on the falling tide to reinforce the tidal ebb current, if experience shows that the permanent exclusion from the harbor of the free tidal action of the basin

actually causes changes in the bed of the upper harbor or the channels leading therefrom and thereinto, injurious to the port or damaging to the maritime interests of the city.

There are to be five of these sluiceways, each 30 feet wide, with elevation of sill placed 5 feet below mean low water, making the full water way of each sluice below elevation 8 in the basin, 390 square feet and of the five sluices, 1,950 square feet. The area of free discharge, between elevation 8 and mean low water, of these five sluices will be equal to 1,200 square feet. With a velocity averaging 2 feet per second on the area of 1,950 square feet, the discharge of water through these five sluiceways will be 3,900 cubic feet per second, or about 337,000,000 cubic feet per twenty-four hours; with an average velocity of 3 feet per second, 5,850 cubic feet per second, or about 505,000,000 cubic feet per twenty-four hours; with a velocity averaging 5 feet per second, 9,750 cubic feet per second, or about 842,000,000 cubic feet per twenty-four hours.

The total discharge through the dam then, if all of the openings described were provided, would be as follows: —

Velocities.

2 Feet per Second.	3 Feet per Second.	5 Feet per Second.
Per 24 hours, 535 million cubic feet.	Per 24 hours, 803 million cubic feet.	Per 24 hours, 1,338 million cubic feet.

The basin formed by this dam, if located just above Craigie bridge, will have an extreme length of about 8 miles, its upper end being near the lower dam at Watertown; its length measured to Brookline Street bridge will be a little less than 2½ miles; its width at the widest point, from the angle on the Beacon Street side at Arlington Street to the west end of West Boston bridge, will be 2,500 feet, or very nearly half a mile. Its water surface below Brookline Street will be 550 acres; from Brookline Street to Watertown dam, 280 acres; total water surface, 830 acres.

The high-water area of this basin between Craigie bridge and Brookline Street was, in 1853, 2,100 acres; by the filling in of the Back Bay and Cambridge lands, the area of 1853 has been reduced from 2,100 acres to 550 acres, — a reduction of 74 per cent.

The area of exposed flats and marshes between high water and low water in 1853 was 800 acres and there have been filled, in addition to these flats, 750 acres of shoal water beyond the low-water mark. The total displacement of tidal water by filling between mean high and mean low water marks has been 174,000,000 cubic feet; beyond and below low-water mark, 392,000,000 cubic feet, — a total of 566,000,000 cubic feet. The storage capacity of the present basin at mean high water between Craigie bridge and Brookline Street is 333,000,000 cubic feet, of which 60,000,000 cubic feet will lie in the stratum measuring 2 feet in depth below mean high water and 273,000,000 cubic feet below elevation 8. The total storage capacity of the present basin (within the harbor lines defining the proposed basin) below mean high-water level between Craigie bridge and the first dam at Watertown is, as near as can be estimated, 466,000,000 cubic feet, of which 84,000,000 cubic feet will lie in the upper stratum of 2 feet, leaving 382,000,000 cubic feet below elevation 8. Thus there has been displaced by filling, 566,000,000 cubic feet of water as compared with 466,000,000 cubic

feet remaining, which is a reduction in total water volume of 55 per cent. (566 + 466 = 1,032. 566 ÷ 1,032 = 55 per cent.).

Of the 466,000,000 cubic feet now contained in the present basin at mean high tide, 323,000,000 cubic feet are stored between mean high water and mean low water. The quantity of water *between these two planes* which has been displaced by filling since 1853 is 500,000,000 cubic feet, or 55 per cent. more than the amount which will be taken out of the range of mean tidal action by the construction of the proposed dam (500 — 323 = 177 ÷ 323 = 55 per cent.).

With an average range of tide of 10 feet there will be on a falling tide a period of four and three-fourths hours during which water may be discharged from the basin to reinforce the tidal ebb current below the dam. If the reinforcing of this ebb current during the falling of the tide through the last 2 feet of the tidal range should prove to be undesirable (as very likely might be the case), then the period of discharge of water from the basin should be reduced to about three and one-half hours. The quantities of water discharged from the basin in each of these two periods at the velocities stated above would be: —

Velocities.

2 Feet per Second.	3 Feet per Second.	5 Feet per Second.
Per 24 hours, 535 million cubic feet.	Per 24 hours, 808 million cubic feet.	Per 24 hours, 1,338 million cubic feet.
Per 4¾ hours, 106 million cubic feet.	Per 4¾ hours, 159 million cubic feet.	Per 4¾ hours, 265 million cubic feet.
Per 3½ hours, 78 million cubic feet.	Per 3½ hours, 117 million cubic feet.	Per 3½ hours, 195 million cubic feet.

To compare these discharges with the present tidal ebb flow from the basin, there should first be noted the 84,000,000 cubic feet of water now held in the upper 2 feet of the basin at mean high water. This quantity is now discharged through the channel at Craigie bridge during the first seventy-five minutes of the ebb tide.

There will be 239,000,000 cubic feet of water stored in the proposed basin between elevation 8 and mean low water, of which about 200,-000,000 cubic feet will lie between elevation 8 and elevation 2, leaving about 40,000,000 cubic feet between elevation 2 and mean low water. This latter quantity of 40,000,000 cubic feet would be withheld from the ebb flow if the discharge from the basin should be stopped when the harbor tide had fallen to elevation 2.

In the present basin, on an average tide, there is now available for the ebb flow 323,000,000 cubic feet of water; deducting the 40,000,000 cubic feet below elevation 2, on the assumption that the ebb flow in its last stage (lower 2 feet) is likely to be detrimental rather than valuable, there is remaining the quantity of 283,000,000 cubic feet; deducting the volume of 195,000,000 cubic feet (the discharge through the openings in the dam in three and one-half hours), and the loss in volume is 88,000,000 cubic feet, or 31 per cent. of the present volume (323 — 40 = 283 — 195 (three and one-half hours) = 88 ÷ 283 = 31 per cent.).

If it should prove that the present entire ebb flow has a practical value, then the loss in effective volume would be but 26 per cent. (323 — 239 (total storage) = 84 ÷ 323 = 26 per cent.).

In laying out the dam for construction, the lock should be located at or near the Cambridge end, with the greater part of its length projecting into the basin. The eight ports for regulating the water level in

the basin should be located next to this lock, with the westernmost port distant about 50 feet from the inside face of the easterly lock wall. The wasteway containing the five water ways should be located at the Boston end of the dam, and the main tidal sluiceways (if it is found desirable to provide them) should be located next east of the regulating ports on the Cambridge side to secure the discharge of the great volume of water which they will pass into the deepest tidal water below the dam. A drawbridge will of course be required across the lock.

There may be variations in these locations, — a further study may show that the order of location may be reversed; but I assume the capacities of these various openings and sluiceways will be amply sufficient for the purposes for which they are designed.

All of the gates and sluices controlling the other water ways should be placed on the basin side of the dam and just outside of the line of coping of the retaining wall. This arrangement will provide for the operating of any or all of the gates and sluices without interfering with the free use of the roadway and sidewalks.

It is proposed to operate by electric motors all the gates and valves controlling the lock, for filling and emptying the lock, and the gates and sluices controlling all of the other water ways. Provision for the location and protection of these motors, with their switch-boards and accompanying mechanical connections with the shafting and hoisting arrangements moving the gates and sluices, is to be made by constructing suitable buildings and chambers of pleasing exterior design.

The choice of location for the proposed dam must be made from the points of view of utility and expediency, and these two essential considerations can best be discussed after studying the relation which the proposed basin bears to the conditions and interests which will or may be affected by its establishment and maintenance. Wherever the dam may be located it will divide these conditions and interests into two convenient parts.

The construction of the dam and the maintaining of the water level in the proposed basin at elevation 8 will be of practical value to the owners and users of wharf property fronting upon or reached from the basin, in that it will enable vessels to reach any or all of the wharves at any hour of the day or night, and will thus greatly facilitate the unloading of cargoes and the moving of the vessels and barges up or down the line of the lock, and from the lock out into the open water way where they can be moored out of the way of other vessels which it is desired to tow into the lock, and where they can be passed in rapid succession through the lock into the tidal harbor below.

Above the Dam the study will include certain practical questions of a sanitary nature, certain effects upon present municipal structures and provisions, and various projected public and private improvements. Concerning all of these matters much official information and many opinions have already been publicly presented, but it appears necessary at this time to refer only to such facts in the case as may be directly involved in the proposition to create the fresh-water basin.

First, as to the basin itself. It is now merely a tidal reservoir of dimensions fixed by the establishment of arbitrary lines very properly laid down to define private and public interests of increasing value and importance to the municipalities bordering upon it. About twice a day, or 705 times in the year, this basin is drained by the recession of

the tide, and as many times in each year is filled again, often to overflowing, by the rising tide. As it is emptied on the falling of the tide the 323,000,000 cubic feet of water which it contains above the plane of mean low water pass out of it in a brief space of six hours, leaving uncovered its unsightly bottom. But the rising tide when it refills the basin does not return 323,000,000 cubic feet of clean sea water; it returns in a large part such impurities as flowed out on the preceding ebb tide, plus some additional impurities from other parts of the tidal area contributing to the flood tide. On the rising tide all of the impurities which have accumulated between tides in the upper harbor are forced back again toward the head of this harbor and into the Charles River and Mystic River channels, but the Charles basin, being much the larger of the two tidal basins receives the greater part of the flood water. The returning tidal water which enters this basin will contain not only such proportion of its former impurities as may be conveyed by the flood current, but additional impurities which on the ebb and flood tides found their way into the upper harbor from all of the tidal basins above the seaward outlets of that harbor.

Interior tidal basins within the natural drainage area of large manufacturing and commercial cities are temporarily rendered less unsightly by filling at high tide, but this very process of refilling washes back into them the débris and floating filth which inevitably find their way into the harbor channels from various sources, and leaves them as the tide falls, in the slips between the docks and in the shoal water on the edges of the basin.

The only appreciable dilution which the flood tide water receives in the case of the Charles basin comes from the inflow of the clean, fresh water which flows, in varying quantity, at all times of the year from the drainage area above the Watertown dam.

It is important to determine the amount of this clean, fresh water, and the following table shows, in cubic feet per twenty-four hours, and per month, for each month of the year, the quantities of fresh water which will flow into the proposed basin in years of average and minimum water-shed yields: —

MONTHS.	Average Year (Twenty-six Years, 1875-1900) — Run-off in Cubic Feet		Minimum Year ([illegible]). — Run-off in Cubic Feet.	
	For Twenty-four Hours.	For Month.	For Twenty-four Hours.	For Month.
January, . .	35,454,240	1,099,081,440	9,712,224	301,078,944
February, .	61,401,888	1,719,252,864	29,960,928	838,905,984
March, .	94,981,248	2,944,418,688	46,721,664	1,448,371,584
April, . .	62,845,632	1,885,368,960	39,147,840	1,174,435,200
May, . .	37,085,472	1,149,649,632	27,204,768	843,347,808
June, .	14,117,760	423,532,800	8,699,616	260,988,480
July, .	5,530,464	171,444,384	3,355,776	104,029,056
August, .	8,624,448	267,357,888	2,268,864	70,334,784
September, .	7,049,376	211,481,280	2,643,840	79,315,200
October, .	14,154,912	438,802,272	5,380,992	166,810,752
November, .	27,222,912	816,687,360	5,943 456	178,303,680
December, .	34,966,080	1,083,948,480	5,605,632	173,774,592
Totals, .	–	12,211,026,048	–	5,689,696,064

Total area above Watertown dam, 270 square miles, less area equivalent to right of diversion into the Neponset River via Mother Brook canal, 68 square miles = 202 square miles; less the area diverted by Cambridge, 22 square miles = 180 square miles; plus area below Watertown dam, 37 square miles = 217 square miles, which area is used, together with the Sudbury River records, in preparing the table.

Q. (by Colonel MANSFIELD). How long a period of time does that observation of the Watertown dam cover? A. Twenty-six years. I beg pardon, there are no observations at that point continuous and accurate enough to furnish the figures which I present here. The records of flow, so far as they have been made, relate mainly to the depth of water going over the dam. After the water in the river reaches certain stages, the data or records which have been accumulated are not particularly valuable in determining the amount of water running in those periods. The calculations I have presented have been checked so far as those measurements and records were useful, and by comparisons in other directions; and they are believed to be, and are offered as being, as accurate as it is possible to obtain figures showing the run-off of fresh water from the watershed.

This table shows that in the year of average run-off there will flow into and through the basin 12,211,000,000 cubic feet; in a minimum year, about 5,640,000,000 cubic feet. This annual run-off of an average year will fill the proposed basin (containing 382,000,000 cubic feet below elevation 8) thirty-two times, — an average of a little more than two and one-half times per month; the annual run-off of a minimum year will fill the proposed basin fourteen and three-fourths times, or averaged over the year, about once in three and one-half weeks.

I should say that the areas and figures in this table are not applicable to present conditions, as the fresh-water flows to-day are in excess of those given. The table is intended to show the run-off from the Charles River drainage area after the water which may be legally diverted is taken out.

The engineer of the State Board of Health, using the best data available, estimated the discharge of the river at the lower Watertown dam at the time of the extreme freshet of February, 1886, to be 5,200 cubic feet per second. Taking into account the drainage area below the Watertown dam, this extraordinary rate of flow may be increased to 5,600 cubic feet per second to represent the quantity of water which, with a repetition of the conditions of the 1886 freshet, would probably be discharged into the proposed basin. At this rate of flow the proposed basin would be filled with fresh water in about nineteen hours.

To accumulate the 239,000,000 cubic feet which will be contained in the proposed basin between elevation 8 and elevation 0 will require but about eleven and three-fourths hours, at this rate.

The yield of the average year will deliver this quantity of 239,000,000 cubic feet fifty-one times, or on an average, once in seven and one-fourth days; the yield of the minimum year, twenty-three and one-half times, or on an average, once in fifteen and one-half days.

The high-water surface of the proposed basin will be 830 acres, and a depth of 12 inches of water on this surface will be equivalent to 36,000,000 cubic feet.

The following diagram (A) shows the rate of evaporation from this surface and the rainfall, both plotted on the same scale for comparison, for average, maximum and minimum years. An inspection of the diagram shows that in a year where the maximum evaporation and the minimum rainfall coincided there would be a net loss in depth by evaporation, only in the months of April, June, July, August, September and November. But the factor of evaporation may be entirely disregarded in this case so far as its effect upon the lowering of the water surface of the basin is concerned. The greatest evaporation shown on the diagram is less than 7½ inches in the month of August, and this depth of water on the surface of 830 acres would be equivalent to 22,500,000 cubic feet. From the above table of water-shed yields in a minimum year it will be seen that the run-off in the month of August is likely to be as low as 70,000,000 cubic feet, but more than three times as much as the quantity which the records show might be evaporated from the entire basin surface in that month.

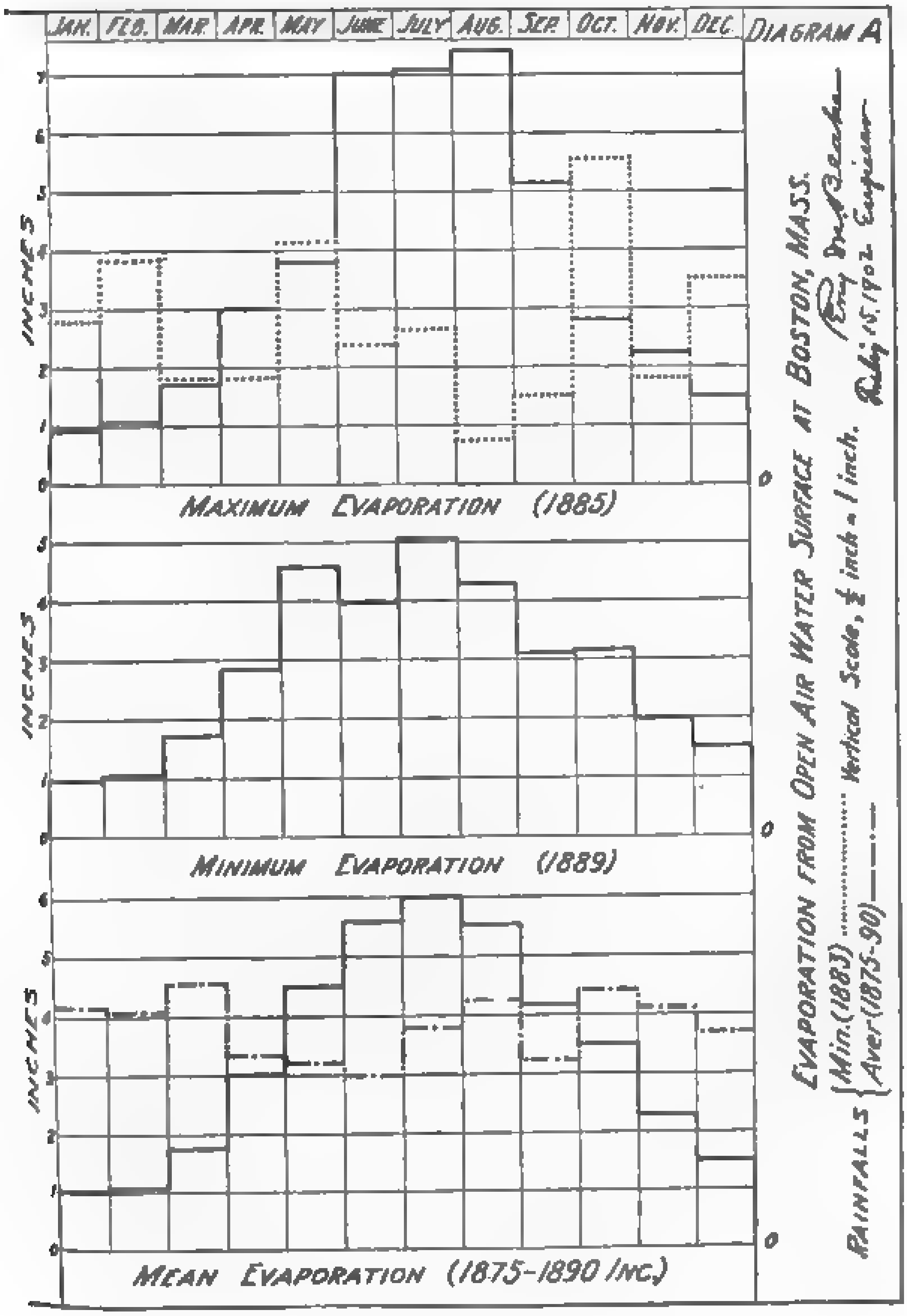
The quantity of water which may be lost by evaporation will enter into the question of the purity of the water stored in the basin as it will be supplied from the inflowing water of the river. Accordingly there must be taken into account, in arriving at the degree of circulation in the stored water, the diminution in the amount which can be wasted through the dam in the drier months of the year.

The diagram (A) shows a possible maximum evaporation during the whole year of 43.63 inches and the coincidence of a possible minimum rainfall of 32.78 inches, showing an excess of evaporation of 10.85 inches. Such a net loss by evaporation would be equivalent on the surface of the proposed basin to the quantity of 32,500,000 cubic feet. The greatest difference between evaporation and rainfall would probably be in the month of August, when the net loss due to the excess of evaporation over the amount of rainfall on the surface of the basin might be equivalent to 6⅔ inches, equal to the quantity of 20,000,000 cubic feet, or about 5 per cent. of the total quantity of water stored in the proposed basin. These losses are so small that they may be disregarded. In a year of average evaporation and rainfall the latter would be equivalent to 45.8 inches and the former to 39.2 inches, making an excess of rainfall of 6.6 inches, so that for the year there would be no loss by evaporation.

Discharging into the present basin are certain sewer outlets, most of which are controlled by regulating devices and tide gates used in con-

nection with the metropolitan intercepting sewers, which so operate that the discharges from these outlets are comparatively infrequent.

On the Cambridge side of the basin there are twelve of these outlets constructed at different elevations. The largest of these is known as



the Binney Street outlet and is located 1,900 feet above Craigie bridge and 1,300 feet south of the location selected for the proposed dam by the commission of 1894. On the Boston side there are fifteen of these outlets, constructed at varying elevations, the largest of which are the

Stony Brook conduit, the Muddy River conduit and the former Brookline main sewer outlet near St. Mary's Street.

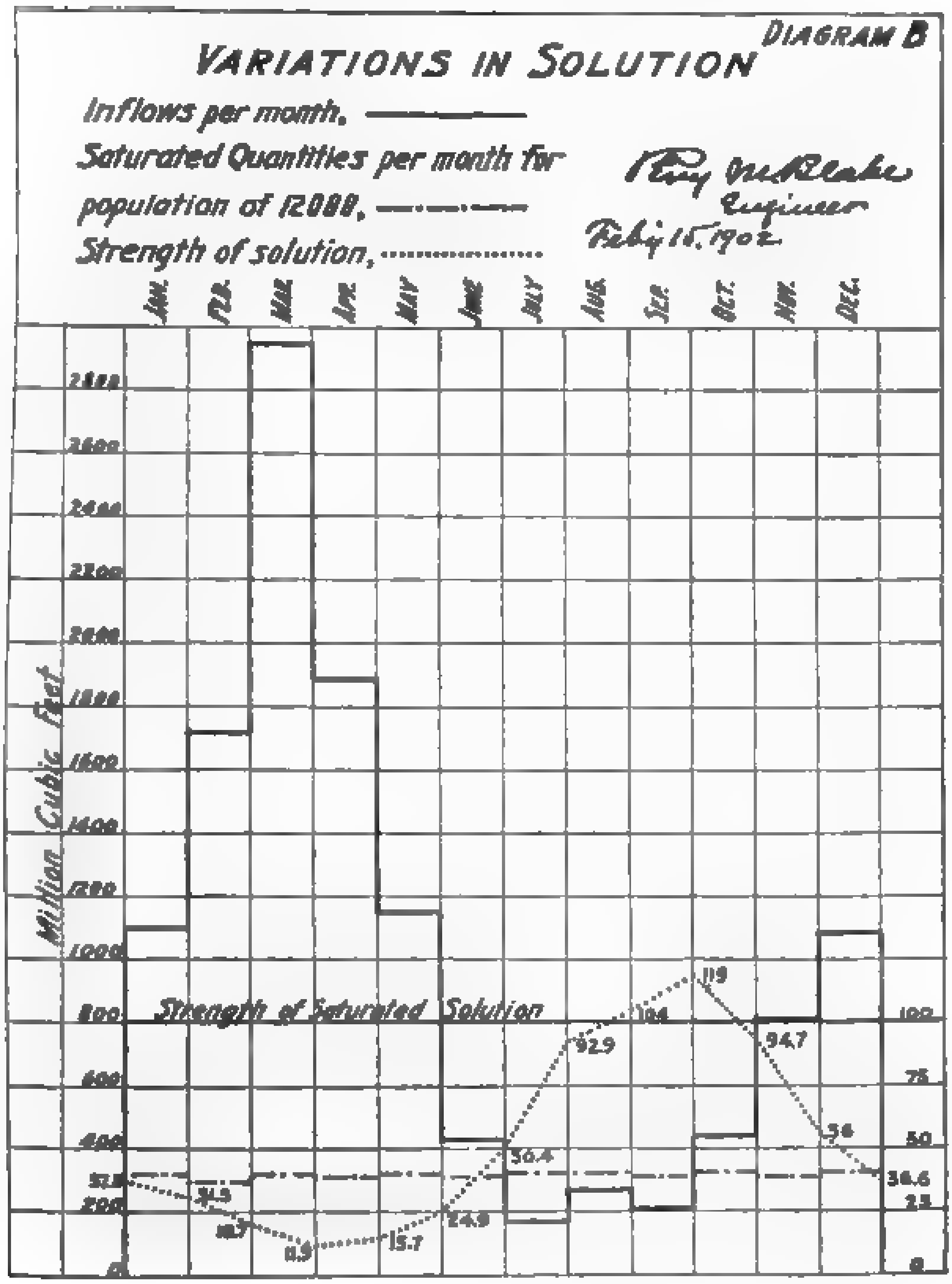
Certain estimates have been made and presented in this case, intending to show the probable amount of sewage discharged during the year into the present basin. It is a popular belief that at each ebb tide such of this pollution as will float or be transported by the currents induced by this tide is drained out of the basin, into the harbor and thence seaward, but the fact is that a considerable portion of this pollution is returned to the basin on each flood tide. If the proposed dam is constructed and the water level in the basin maintained at elevation 8, these sewage discharges will be injected into the stored water and must depend for their dispersion, destruction or removal upon such forces as may be put in operation in the basin or created in regulating the admission and wasting of water, through the appliances and methods employed in the design and construction of the dam and its water ways.

It is conceded by the best sanitary authorities that a flow of 10 cubic feet of water per second per 1,000 persons is amply sufficient to take care of and so dilute the sewage from such population as to render the stream receiving the sewage entirely unobjectionable to persons who may live near it or sail over its surface. At the rate of this allowance, the total quantity of clean water per day required to so dilute the sewage of each population of 1,000 persons would be 864,000 cubic feet. To dilute the sewage of a population of 12,000 persons would require a flow of 10,368,000 cubic feet of clean water per day.

Assume the proposed dam to be completed, its lower water ways ready to be closed and 143,000,000 cubic feet of water lying stored below low-water mark, in the basin behind the dam. Assume all of the water ways to be closed on the first day of December in a year of average water-shed yield; at the rate of the above requirement, the 239,000,000 cubic feet of water, which would be accumulated in the proposed basin up to its overflow in six and five-sixths days, would render innocuous beyond question the sewage discharged from a population of 276,620 or at the rate of 40,481 persons for each day or nearly three and one-half times the population of 12,000.

The total quantity of water required to dilute the sewage from a population of 12,000 persons for six and five-sixths days would be equal to about 71,000,000 cubic feet, and it will be convenient to call this quantity of polluted water a *saturated solution*, the exact chemical composition of which we may not here be able to determine with precision, but the strength of which may be represented by 100. It follows then, that variations in the amount of clean water flowing into the basin will affect the purity of the contents and the result of a study in this line shows that at the end of December the strength of the solution will have been reduced to 37.8; at the end of January, to 31.5; at the end of February, 19.7; at the end of March, 11.9. During the month of April the strength of the solution will slowly increase so that at the end of that month it will be 15.7; at the end of May, 24.9; at the end of June, 50.4; at the end of July, 92.9; at the end of August, 104; at the end of September, 119.4. During the month of October the solution will begin to grow weaker, being at the end of that month 94.7; at the end of November, 56; at the end of December, completing the cycle of the average year, 36.6. These results are expressed graphically on the following diagram (B), which shows that while in September the strength of the solution may be temporarily increased 19 per cent., reducing the 10 cubic feet of clean water per second per 1,000 persons to 8.4 cubic feet per second, at the end of the cycle in December the GAIN in purity over the degree at the starting point twelve months earlier is measurable.

Q. (by Mr. Dunbar). Will you kindly explain to me how you get your basis of 100 for your "saturated solution?" A. I will make that a little clearer, perhaps, by referring directly to diagram B. The broken line at the bottom is the quantity of water at the rate of 10 cubic feet



per second per 1,000 persons required in one month to dilute the continuous flow of sewage from a population of 12,000. Running up the line toward the top of the diagram the heavy black lines indicate the total inflow of clean water during that month.

Mr. MATTHEWS. The line showing the strength of the saturated solution is the line of safety.

The CHAIRMAN. He has simply taken that as an arbitrary line to measure by, and the rest is a matter of calculation.

Thus the continuous flow of sewage from a population of 12,000 at the rate of 10 cubic feet per second per 1,000 persons, will be rendered innocuous in a year of average water-shed yield. Such sewage as may find its way into the proposed basin will first be mixed with storm water, and the frequency of the overflowing of the sewers and the discharge of storm water depends upon the frequency and amount of the rainfall; hence, in a year of minimum water-shed run-off there would be a minimum amount of rainfall and a less frequent flooding of the sewers.

The facts disclosed by the calculations shown on the diagram are applicable in this case to a year of minimum rainfall, *i.e.*, the overflow discharges of storm water and sewage into the proposed basin will fluctuate in the same degree that the inflow of clean water into the basin will fluctuate. But the study should not stop here.

The city engineer of Cambridge has presented certain information concerning the overflow discharges from two principal sewers, the lower and larger of which is in Binney Street, the other in Bath Street, both being shown on the map. A large part of the Cambridge sewer system is constructed and now operated on the "combined plan," *i.e.*, the sewers receive surface water through catch-basins in times of rainfall and when snow is rapidly melting, which, mixed with the sewage proper, flows into the metropolitan intercepting sewer. When a certain limit of the carrying capacity of the latter sewer is reached, regulating devices actuated by a back flow therein partially or wholly close the connection with the local sewer and compel the local flow to find its vent through the outlets discharging through tide gates into the river basin. Certain estimates of the quantity of mixed sewage and storm water which is discharged through these direct outlets have been officially presented in this case, based upon rather meagre information and the judgment of the authorities having in charge the management of the sewer system. A part of this information consists of records made by automatic registering appliances attached to tide gates and regulators. The sizes and elevations in reference to mean low water of the sewer outlets on both the Cambridge and Boston sides of the basin are also on record and the more important of these figures may be used in arriving at conclusions which may be applied in this case.

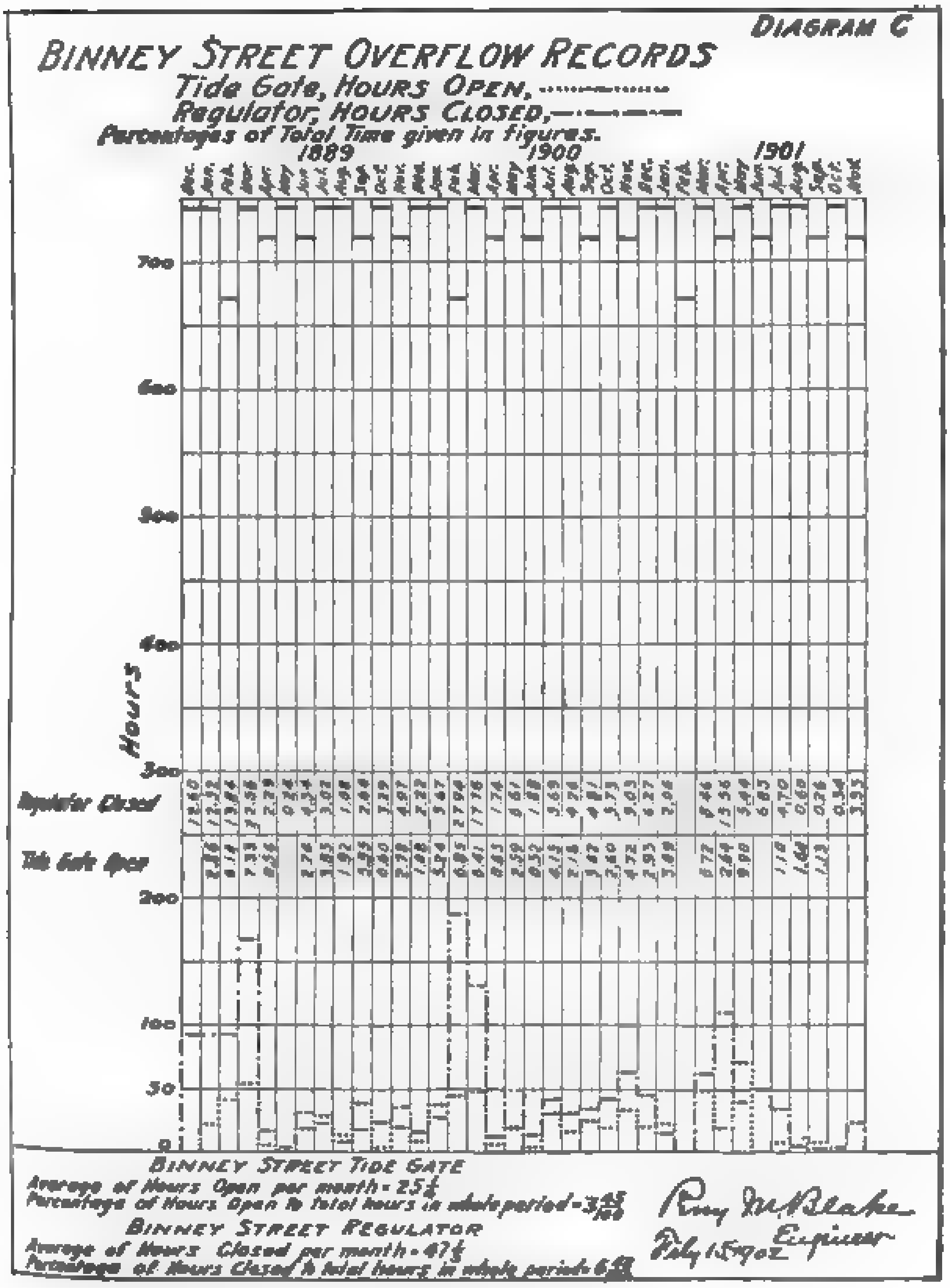
The city engineer of Cambridge presented a table expressing in total hours the time in which those appliances were in operation, closed or open.

Q. (by the CHAIRMAN). Open or closed per year? A. Yes, sir. I have examined the records themselves, and with his approval have prepared the data which I am about to put in now.

First, the main or Binney Street sewer, originally constructed for the purpose of conveying directly into the river basin the sewage of a populous part of Cambridge, — and which now serves as a storm overflow outlet to take such sewage and storm water as the metropolitan sewer cannot convey, — is provided at its outlet with a tide gate and at its con-

nection with the metropolitan sewer in Portland Street with a regulator, and a memorandum of the times when this tide gate has been open and this regulator has been closed has been kept from January, 1899, to October, 1901, — a period of two years and nine months.

The following diagram (C) shows graphically the hours in each



month of the record when this tide gate was open and this regulator was closed, and by figures, the ratios of time which these hours bear to the total hours in the month.

To illustrate, the Binney Street tide gate was open in the month of January, 1899, 21¼ hours, or 2.86 per cent. of the time in that month; in February, 1899, 41¼ hours, or 6.14 per cent. of the total time; in

August, 1899, 14¼ hours, or 1.92 per cent. of the time; in December, 1899, 8 hours, or a trifle over 1 per cent. of the time. The Binney Street regulator (at Portland Street) in the month of December, 1898, was closed 93¾ hours, or 12.6 per cent. of the time; in March, 1899, 167¾ hours, or 22.55 per cent. of the time; in August, 1899, 8 hours, or a little more than 1 per cent. of the time; in February, 1900, 187¾ hours, or 27.94 per cent. of the time; in November, 1900, 65 hours, or a trifle over 9 per cent. of the time.

The average hours-open per month for the whole period in the case of the tide gate was 25¼, or 3.45 per cent. of the total hours of the whole period. If these tide gate hours-open represent the time when overflows of sewage took place, the population contributing the sewage which escaped during this time would be equivalent to 347,826, if estimated upon a basis of 12,000 discharging sewage all of the time ($12{,}000 \div .0345 = 347{,}826$). In other words, the sewage of a population of 347,826 discharged in 3.45 per cent. of the entire year would be no greater than the continuous discharge from a population of 12,000.

The average hours-open per month of the Bath Street tide gate was 31¼, or 4.28 per cent. of the total hours of the whole period (diagram D). Using this record and estimating as before, the population contributing sewage which escaped during this time would be equivalent to 280,373.

The average hours-closed per month of the Binney Street regulator was 47⅛, or 6.48 per cent. of the total hours of the whole period. Using these figures, and again estimating by the same method, the population contributing sewage which was forced through the overflow channels by the closing of this regulator would be equivalent to 185,185. This population is much smaller than that obtained by using the record of the tide gate.

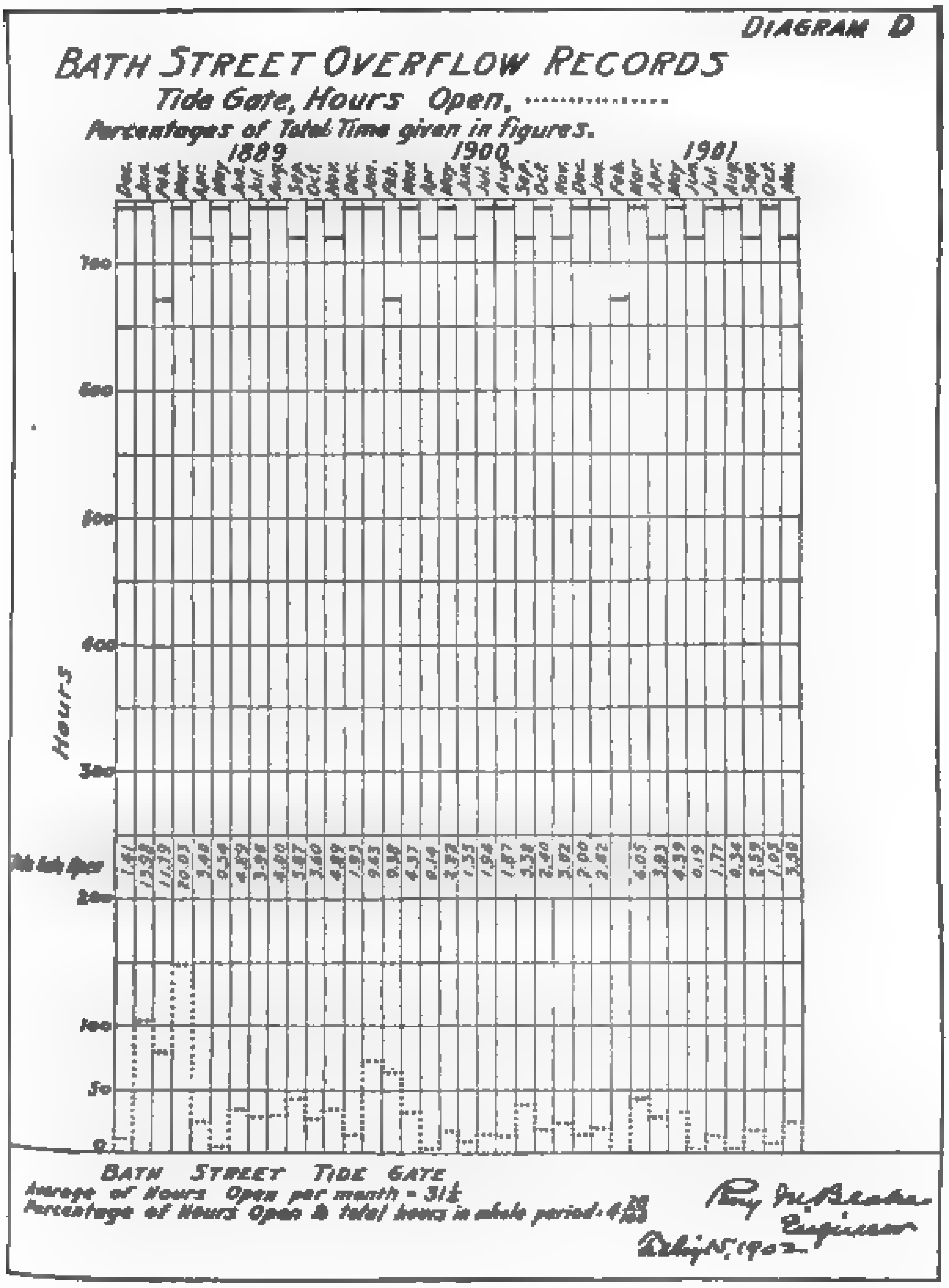
The difference in hours between the tide gate and regulator is no doubt due to the fact that the Binney Street sewer, acting as a storage reservoir, accumulated sewage during the hours indicated by the regulator record and discharged it during the hours when the tide gate was open.

The records of the regulator on the Massachusetts Avenue sewer, wasting into Alewife Brook outside the water-shed of the Charles River, furnish the following data, the record beginning in May, 1899, and extending, with a few interruptions only, to November, 1901. The average hours-closed per month for the period was about 33½; the percentage of the total time of the record of the hours-closed was 4.58 per cent., and the population indicated (calculated as before) is 262,009.

It is hardly necessary to pursue this line of study farther, as it is evident from these figures and from an ordinary knowledge of the facts in the case that no such population now exists on the lines of sewers now forming the combined systems which discharge storm waters into the present basin. This conclusion takes into account the sewerage details on both sides of the river. It is the opinion of the municipal authorities of both Boston and Cambridge that separate sewers should be constructed as substitutes for the present combined sewers and it is in evidence that work in this direction has already been begun and is likely to be continued on the grounds of efficiency and economy in the maintenance of the metropolitan sewage pumping plants.

In the above discussion of the tide gate and regulator records it is assumed that the storage and overflow of sewage in the cases cited are generally typical of other parts of the combined sewer systems which overflow into the present basin.

The city engineer of Cambridge in a special report to the Cambridge city council in 1897 states, when referring to flooding of cellars by the backing in of sewage at times of high tide, that "Every foot taken from the elevation of high tide is equivalent to a similar amount added to the inclination of a sewer."



A disastrous and expensive flooding of cellars and basements may be caused by one high tide; as compared with a permanent high-water mark at elevation 8, the basin is now subject to occasional flood tides reaching elevation 13, or 5 feet above the high-water level proposed for the fresh-water basin. The construction of the proposed dam and the permanent exclusion of tidal fluctuations will protect the lower

sewers on both sides of the basin from all dangers of back flooding from high water and the gain in head in discharging capacity in the sewers on the lower level will be increased from 2 to 4 feet. Under present conditions there is but little opportunity to enter and examine the larger and lower sewers and it is known that some of these sewers are seldom cleaned and most of them so infrequently, that in times of flood and scouring through the overflow outlets the heavier and filthier sediment which has accumulated in the bottom of the sewer is washed out into the river. It is now frequently the case when a high tide and rainfall occur at the same time, that this offensive sediment and accumulation is forced back into the upper ends of the lower sewers and through some of the lower lateral sewers into cellars and basements, adding to the measure of damage by the filthiness of the liquid.

After the proposed dam is constructed and put in operation it will be entirely feasible to draw off the upper 6 or 7 feet in depth of the fresh water in the basin and hold the water level in the basin down for several days at a time to a level but little above the present mean low-water mark, thus affording ample time to allow of the thorough inspection, cleaning and repairing of the low-level sewers and their overflow outlets. By taking advantage of such an opportunity the offensive deposits in these lower sewers may be largely removed, with the result that storm overflow discharges following would be much cleaner in character.

Certain natural forces will operate in all parts of the fresh-water basin to create local circulation, such as changes in temperature in the upper layer of water, wind action and a measurable degree of chemical activity. All of these forces will aid in the dispersion and destruction of such impurities as may find their way in limited quantities through the storm water overflows into the basin. It may be desirable to extend into deeper water some of the larger overflow outlets on the shallower shores of the basin and this can be readily done after the dam is constructed and the tide waters kept out.

The plan of the city of Boston for extending the Stony Brook conduit from the Fens to the river to provide for the flow of the first of the storm water with the scourings of the conduit into the river, and the subsequent and cleaner flow into the Fens basin, is as desirable now as it will be after the proposed basin is constructed. The present plan of creating a circulation in the Fens basin and renewing its contents, which at the best gives but partially satisfactory results, cannot be continued if the permanent water level at elevation 8 is maintained after the proposed dam is constructed, but the water which is now available on the flood tide for circulating through the Fens basin is mainly salt water of a composition far from clean. There will be no difficulty and but a reasonable expense involved in greatly improving by artificial, mechanical means the character of the Fens basin, if fresh water is stored in the Charles basin at the permanent elevation 8. A small pumping station may be located near the gatehouse on Brookline Avenue (point P on map) and the Fens water raised about 3 feet by inexpensive pumping machinery and allowed to flow back into the Charles basin through the conduit in Brookline Avenue; the supply of fresh water for refilling the Fens basin to be furnished through the gates at Beacon Street which are of ample capacity to pass all of the water required for this purpose. This will be clean, fresh water and the effect of the improvement will be seen immediately.

The device for accomplishing this improvement may consist of a pumping engine of the propeller type. The quantity of water which the Fens basin is estimated to contain is about 8,000,000 cubic feet; to renew this quantity of water in twenty-four hours by the plan outlined

would require the exertion of about 50 horse-powers in the type of engine proposed (efficiency of engine, 65 per cent.). A similar plan for creating a circulation and renewing stagnant water is in successful operation in the city of Milwaukee, Wis., where water is forced from Lake Michigan into the upper part of the Milwaukee River and creates a flow in that river back into the lake. In the case of the Fens basin, the cost of the pumping engine, with its boilers and connections, should not exceed $20,000; the engine pit, special water ways and foundations, $10,000; and a building to contain the plant, designed in harmony with the artistic surroundings could probably be erected for a sum not exceeding $20,000. The care and operation of this plant would be of a simple nature and the total cost of operating it, say twice a week for eight months in the year, should not exceed $6,000 per year. The improvement in the appearance of the Fens resulting from the adoption of such a plan would warrant a much larger expenditure than this.

The surface of the water in the Brookline, Muddy River basin, including Leverett Pond at its upper end, is maintained at elevation 11 and this water is drained off into the Fens basin through the gate house near Brookline Avenue, the difference in level of the two water surfaces being 3 feet. The water in the Brookline basin is far from clean, and owing to the small size of the drainage area furnishing the water there is very little circulation in the basin. The plan proposed for renewing the water in the Fens basin may be turned to good account in replenishing the water in the Brookline basin. By lowering the water surface in the proposed Charles River basin, say to elevation 5, both the Brookline and Fens basins may be practically drained down to that plane. Upon the refilling of the Charles and Fens basins to elevation 8 with fresh water, so much water as may be needed may be drawn from the latter and raised by the pumping engine into the Brookline basin until the latter is refilled with clean water to its customary elevation 11.

The main ground of complaint as to the condition of the Fens basin in the past had for its reason the accidental discharge on two recent occasions of large quantities of sewage from the Stony Brook channel, — an occurrence not likely to be repeated. The Stony Brook conduit, it is believed, has been neither thoroughly inspected nor cleaned with that care and frequency with which such work may be readily done after the tidal flow is excluded by the proposed dam and the water level held at a low stage in the proposed basin. It has a direct connection through its bottom with the metropolitan sewer where the latter passes below it, and a considerable quantity of the ordinary Stony Brook flow can be turned into the metropolitan sewer through this connection.

The new metropolitan high-level sewer now being constructed is designed to receive the sewage of the Charles River valley sewer now flowing into the Boston main drainage sewer. The pump well of the new high-level sewer pumping station to be constructed near the corner of Ward and Vancouver streets will have its water level about 5 feet lower than the Charles River valley sewer at the point of diversion in Huntington Avenue and when this pumping station is in operation the relief of the latter sewer will be effected as it will be free to flow without the retarding effects now caused by its draining into the Boston main sewer and the capacity of its lower sections will be much greater than at present.

The point where the Charles River valley sewer will be diverted into the pump well of the new high-level pumping station is in Huntington Avenue at Ruggles Street and the section of sewer in Huntington Avenue between Ruggles Street and Gainsborough Street, now form-

ing the extension of that sewer to the Boston main sewer through which the sewage collected by the Charles River valley sewer now flows into the Boston sewer may be disconnected near the latter sewer and its flow, received from local connections, reversed so that it will be discharged into the pump well of the new high-level pumping station.

The point where this extension in which the flow is to be reversed passes under the Stony Brook conduit is at the junction of Parker Street and Huntington Avenue and there is apparently no objection to the discharge of the ordinary flow of water in the conduit into the sewer at this point and thence in the line of the reversed flow to the pump well of the new high-level pumping station. The connection between the channel in the bottom of the conduit and the sewer in Huntington Avenue is of iron, 4 feet in diameter, laid in the form of a siphon, with a connection 35 inches in diameter with the sewer in Huntington Avenue. (See blue-print, — City of Boston, Sewer Department. Outlet of Covered Channels. — Stony Brook Improvement, Sewer Overflow and Intercepting Sewer Connections at Huntington Avenue and Parker Street. Roxbury. 1890. Scale 1″ = 10′.)

Such sewage as is found in this Stony Brook conduit is discharged from sewers in the valley of the brook at such times as the Stony Brook intercepting sewer becomes surcharged. On such occasions the sewage in the latter sewer is greatly diluted by the inflow of surface water so that, with the exception of the first part of the discharge of the Stony Brook conduit into the Fens basin the flow of the conduit consists of comparatively clean water. There is a constant but somewhat irregular flow varying from 1,500,000 to 3,000,000 gallons of water per day flowing from the works of the Boston Belting Company through the old conduit discharging into Charles River and from this old conduit at times into the Fens basin. Under the terms of settlement with the Boston Belting Company the use of this old conduit for conveying the water used by the concern may sometime be discontinued and the upper section of the conduit filled up. It is understood that the city of Boston will before long undertake the extension of the newer conduit from the Fens basin through to Charles River and it is probable that when this is done the old conduit will be abandoned.

My conclusions as to the effect of converting the present tidal basin into a fresh-water basin by the construction of a dam as proposed, and the utility and value of such fresh-water basin when constructed, may be briefly stated as follows: —

The maintaining of a nearly constant water level at the elevation proposed will prevent the overflowing and saturating of a large territory twice a day by tides rising from 2 to 5 feet above the proposed high-water level. This will make easy the reclamation and improvement of large tracts of land which now are of little value and not capable of much profitable improvement.

The volume of clean, fresh water which will feed and maintain the basin will possess elements which will better aid in the destruction of such impurities as may find their way into the basin than salt water. The basin will be cleaner in every respect than it now is and will be without the dam, and much cleaner than it is likely to be in future

years, when the waters of the upper harbor will be dirtier than they now are.

The provision for discharging the water through the proposed dam will be such as to make it feasible to partially or wholly empty the basin in a very short time, should it become necessary to hasten a renewal of its contents; but, in my opinion, a special emptying of the basin at any time for such purpose will never be found necessary. The basin may be emptied, for the purpose of repairing the structures erected along its banks or upon its shores or entering it, from points on either side; and its water surface may be held at a low level for several days at a time, to enable constructions or improvements to be carried on at levels which are now impossible with the free tidal action except by the use of expensive cribs and coffer-dams.

It will have a large value which will be measured in financial returns in the increased values of littoral property on both sides; and, by its natural incorporation into the park and pleasure way scheme of the larger metropolitan district, its practical and æsthetic value will have a wide distribution.

Instead of a more or less dirty tidal basin, into which will be driven on the flood tide impurities and débris from the harbor, it will become a beautiful lake, with a narrow and winding extension, navigable from the landings near the dam at its foot to Watertown; and in the warmer months it may be used by small steamboats, sail boats, launches and small pleasure craft of every description. Its shores at suitable points may be made safe and popular bathing places, and nearly every portion of its banks will be easily accessible to pleasure seekers. In the winter its reaches will furnish most admirable ground for skating, and winter sports, such as are encouraged in northern European cities, will find popular adoption.

An important part of the study is the probable effect of the construction and maintenance of the proposed basin upon the channels and water ways of the harbor. Much information concerning the relation which the present Charles tidal basin bears to these water ways and channels is to be found in the official reports, maps and opinions which have been presented in the past and these, together with the latest data, may be used with profit in arriving at this effect.

The map, in the upper right-hand corner, shows certain channel cross-sections prepared from the best information at hand; the locations of these cross-sections are shown by heavy green lines on the map.

The flood and ebb flows of sea water into and from the inner or upper harbor pass through three channel ways or openings, leading into the outer harbor, viz.: the northernmost, between Jeffries Point, East Boston, and Governor's Island (line No. 3); the eastern and central one, containing the main ship channel, between Governor's Island and Castle Island (line No. 4); the southernmost and smallest, between

Castle Island and South Boston (line No. 5). The total area at mean tide for the first of these channels is 57,241 square feet; of the second, 53,190 square feet; of the third, 14,775 square feet; the sum of these three cross-sections is 125,206 square feet and this represents the area below the level of mean tide through which all of the sea water entering or leaving the inner or upper harbor now passes. As the harbor fills with sea water upon the flood tide a portion of this water flows on and into the basins beyond through the restricted cross-section of the channel between Boston and East Boston (line No. 2 on map), the area of which below mean tide level is 46,414 square feet.

In making the calculations for purposes of comparison the quantity of water forming the tidal prism in the present Charles basin between mean high and mean low tides is taken to be 323,000,000 cubic feet and it is assumed that this water is to be discharged from the basin into the harbor on an ebb flow in six hours, making the average discharge per second 14,954 cubic feet. This rate of discharge on the mean tide cross-section between Boston and East Boston (46,414 square feet) would produce an average velocity of .322 of a foot per second, equivalent to the rate of 1,159 feet or .22 of a mile per hour. The flow of the same quantity of water through the combined areas of the three harbor cross-sections will produce an average velocity of .119 of a foot per second, equivalent to 428 feet, or .08 of a mile per hour or but little more than one-third (37 per cent.) of the velocity on the single cross-section above.

The ebb discharge of the tidal prism from the present Charles basin is augmented by the flow of fresh water coming into this basin during the period of ebb flow. The flow of land water into tidal basins is in many cases regarded as a valuable factor in increasing the scouring power of the ebb flow. It is generally the case however that this land water causes a complication in the tidal conditions and currents of the seaward channels into which it discharges.

The map shows the original shore lines of the upper harbor and the Charles and Mystic basins, the harbor lines officially fixed and laid down by the United States authorities and the proposed ship channel, 35 feet in depth, which is advocated by those who have given the improvement of Boston harbor careful and scientific attention.

It is very interesting to review the original shore lines of this harbor and its connected basins, and compare them with the completed conditions as they are to-day defined by the official lines laid down for future improvements. A careful review of this part of the subject is specially suggested at this time in view of the statement by the Board of Harbor and Land Commissioners in its report of 1894 on the proposed Charles River dam, that "Upon a careful consideration of the testimony presented, and of all the evidence within the knowledge of the Board, we are unable to find the consequences of building the proposed dam as at all certain of being foreseen."

The upper or inner harbor is enclosed by a line drawn from Jeffries Point, East Boston, across Bird Island flats to Governor's Island; from Governor's Island to Castle Island, and from Castle Island to South Boston. On the map the areas colored in pink represent territories which have been or are ultimately to be filled in with solid material, wharves and docks.

Q. (by the CHAIRMAN.) This white area shows accurately the old shore line, does it? A. That shows it as accurately as it was possible for me to determine from the best information I have.

The area which has been and is being filled by solid filling to permanent harbor lines above Craigie bridge on the Charles River has already been stated in figures; the areas taken from tide water below Craigie bridge in the Charlestown district are shown on the map, as is also the area on the harbor front in East Boston and around into Chelsea Creek. The changes in the Charles River basin, beginning more than a century ago have been progressive, although by far the larger part of the filling and improving has been done in the last half-century. In 1859 the progress of improvements in this basin and along the water fronts of the city had reached such a stage that it was deemed advisable to make a scientific investigation of the effect of these shore-line changes upon the navigable channels of the harbor, and upon the request of the city government, a commission consisting of Gen. Joseph G. Totten, chief engineer of the United States Army, A. D. Bache, superintendent of the United States Coast Survey, and Commander C. H. Davis, a prominent officer of the United States Navy, was authorized "to investigate and report upon the condition of Boston harbor, with a view to its preservation and safety for the interests of navigation." This commission made many surveys and a series of reports, to which recourse has been had in this study.

According to the Des Barres map of 1775 the South Bay then consisted of a basin of 160 acres water surface and a surrounding marsh of 380 acres overflowed at high tide, while Fort Point channel had a width of about 1,000 feet. A survey by Lieutenant Wadsworth in 1817 showed this bay in that year to have the same dimensions, or a total of 540 acres water surface at high water, while Fort Point channel had been reduced in width to 450 feet with an increased depth of water in this channel.

The last part of table V in the appendix to the seventh report of the special commission shows the loss of tidal water to be caused by filling in the South Boston flats, South Bay and Fort Point channel from the then high-water mark to the lines laid down by the commissioners. Measuring the loss at an average or ordinary tide, it amounts to 13,526,267 cubic yards or 365,209,209 cubic feet. The area of water surface defined by these lines is 1,270 acres, and the commissioners add to this area as liable to be filled within the lines laid down by them in Charles River, Miller's River, Mystic River, Chelsea Creek and East Boston, 467 acres, making the total water surface to be destroyed, 1,737 acres. The report does not disclose how much of the above area of 467 acres was allowed to be filled in the Charles River basin, but for the following comparison areas are immaterial, as it is known that the quantity of tidal water which has been displaced in the Charles River basin since 1853 is about 500,000,000 cubic feet. Adding to this amount the 365,000,000 cubic feet, which by filling to the commissioners' lines will be removed from the South Boston flats, South Bay and Fort Point channel, the total tidal displacement will be 865,000,000 cubic feet.

Q. (by Mr. PILLSBURY). In what period is that 865,000,000 feet? A. That is based upon the condition in 1775.

Q. (by the CHAIRMAN). That refers simply to the tidal prism of six hours? A. Six hours.

This means that when the above harbor improvements are carried to completion there will flow INTO Boston harbor from the sea on a flood tide 865,000,000 cubic feet LESS than before any improvements were made, and that there will consequently pass OUT of the harbor on the ebb tide 865,000,000 cubic feet LESS than formerly. Of these amounts, the dis-

placement of water in the Charles River basin will in each case be 58 per cent., or a little more than half.

To arrive at a safe conclusion as to the actual value of the ebb flow from the present Charles basin, a discussion somewhat in detail, of certain facts and conclusions placed on record by the special commission in its reports will be helpful.

In the seventh report of the commission (City Document, No. 33, 1864) the commission says, on page 25: "Mr. Mitchell . . . makes the following remarks as the result of his observations and experience: 'There is a positive injury to the basin of the upper harbor, resulting from the existence of extensive flats, covered only by tide water; they add to the scour of the flood, but not to that of the ebb. The effect is that both flood and ebb tend to accumulate deposits near the city. . . .

"'The flood current is an influx from the ocean, under the action of gravity, to restore equilibrium — to equalize pressures. It naturally sweeps along the bottom, for it is crowding up into shallower water as it advances. It lifts the waters in the channels, and overflows the flats. The ebb current resembles a river; it is, in the channel ways of the harbor, compared with the flood, but the confluence of small streams from shallow sources — streams of unequal volume and acquired velocity. The lower stratum of the water in the channel, which felt the *direct impulse of the flood*, is slow to act under the *indirect influence of the ebb.* At the *mouth* of Boston harbor the ebb and flood currents have nearly equal depths of flow, but in the neighborhood of flats the flood is found to be the deeper stream. *If you would add to the ebb scour in the upper harbor, let down its working plane by removing the flats.*'"

On page 52 of the same report Mr. Mitchell in his report to the commission states that: "In the Charles River mouth . . . the constant supply of land waters adds about 10 per cent. to the duration of ebb, and gives to the velocity of the latter [outflow] a preponderance over the former [inflow] of 30 per cent. Of course river water flowing from above will decrease the flood nearly in the same proportion that it increases the ebb."

Also: "No current observations, however nice, can measure accurately that bodily movement of large masses of water which the propagation of the tide wave induces."

The accuracy of this statement may be tested by simple calculations showing the proportion which the amount of land water inflowing during the ebb-tide period bears to the contents of the basin above low-water mark. For convenience the results are expressed in the following table: —

MONTHS.	Inflow of Land Water in Six Hours (Cubic Feet).	Percentage of Tidal Prism of Same.
January, ...	8,863,560	2.74
February, ...	15,350,472	4.76
March, ...	23,745,312	7.35
April, ...	15,711,408	4.87
May, ...	9,271,368	2.87
June, ...	3,529,440	1.09
July, ...	1,382,616	.43
August, ...	2,156,112	.67
September, ...	1,762,344	.55
October, ...	3,538,728	1.10
November, ...	6,805,728	2.11
December, ...	8,741,520	2.71

To make this table simple, I have not put into it the data which I used in making it; they will be found in the preceding table, giving the inflow from the drainage area per twenty-four hours, per month, etc.

These calculations show that instead of there being a "constant" supply of land water the supply is very variable and that with the exception of a few days in the average year when there are freshet flows in the river, the effect of the land water is very far from increasing the duration of the ebb flow 10 per cent.

The velocity values of the flow from the Charles River water-shed in an average year, expressed in ratios of the ebb tide velocity of the discharge of the tidal prism from the present basin through the cross-section between Boston and East Boston (line No. 2) are shown by the following table: —

MONTH.	Run-off, in Cubic Feet per Second, from 217 Square Miles.		Ratios of Land Water Velocities to Tidal Prism Velocities.
January,	410.35	÷ 14,954 =	.027
February,	710.67		.048
March,	1,099.32		.074
April,	727.38		.049
May,	429.23		.029
June,	163.40		.011
July,	64.01		.004
August,	99.82		.007
September,	81.59		.005
October,	163.83		.011
November,	315.08		.021
December,	404.70		.027

This table shows the velocity values of the land water in ratios of the velocity value of the whole ebb tidal prism.

Q. (by Mr. Storrow). When you speak of the volume at point 2, you mean — A. The tidal water in the Charles River basin and the land water coming into the Charles River basin.

They also show that instead of causing a preponderance of 30 per cent. in velocity in the ebb flow over the flood flow the range in difference consists of 7 per cent. in one month, 4.6 per cent. in two months and from 2.7 to ½ of 1 per cent. in the other months; the actual ebb velocities due to land water causing these differences being on the cross-section on line 2, between Boston and East Boston, respectively, .024, .015, .009 and .0013 of a foot per second. (.322 × .074 = .024 = .016 miles per hour; .322 × .048 = .015 = .01 miles per hour; .322 × .028 = .009 = .006 miles per hour; .322 × .004 = .0013 = .0009 miles per hour).

Q. (by the Chairman). You give somewhere the figures and calculations for your conclusions? A. The calculations do not appear here, but I think if you will refer to the figures as given they will explain themselves; I have put simply the results in.

Q. I ask for this reason, — because you are taking, as I understand it, the entire tidal prism, and comparing it. A. Not the entire tidal prism, but that portion held in the Charles basin, and which passes line 2.

The effective water-shed of the Charles River above Craigie bridge is 217 square miles; that of the Mystic River above Chelsea bridge, 60 square miles; the ratio between the two is, — Charles 36, Mystic 10. The pumpage of water from the Mystic lakes ceased in 1898, so that the whole flow of that water-shed is now available for tidal reinforcement, but the velocity values of the flow of land water as a part of the ebb-tide discharge from both basins are insignificant.

While it is true that the structures in the Charles River channel offer some resistance to the outflow of the tidal prism, it is equally true that these obstructions do not alone increase the duration of the ebb flow. The cross-section of the river immediately above Craigie bridge at mean tide has an area of 28,712 square feet, or but 62 per cent. of the section on line No. 2. Were the river channel entirely free from obstructions there still would be, in the difference between the two cross-sections, a cause for retardation of the ebb flow and a prolongation of its duration.

In the ninth report (City Document, No. 28, 1865), page 15, the commission says: "The ebb power to act efficiently upon the main channel of the harbor, must be chiefly exerted during the first five hours. A negative advantage is, that large volumes of running water will not issue into the harbor from the rivers and upper basins at low water."

This advantage will accrue from the construction of the proposed basin, by withholding the lower 2 feet of tidal prism.

On page 17: "A particle of water leaving the Navy Yard on the first of the ebb, may not reach half way to the harbor's mouth before the occurrence of low water; yet, by the action of gravity, the whole body of water in the main channel is carried seaward as the ocean falls away, till an amount equal to the whole tidal prism of the harbor and its tributaries passes through the exterior outlet."

On pages 18 and 19: "A single word on the increase of velocity, which will arise from our improvement, may serve to anticipate inquiry, and allay apprehension. The velocity in the thread or axis of the current, in the strait between Boston and East Boston, as determined by observations at three stations, is, upon the ebb, at an average, 0.55 of a mile an hour, and its maximum 1 mile an hour. The whole amount of mean tide water occupying the basins, rivers, and creeks, above this strait, exceeds at mean high water 40,000,000 cubic yards; and the cross-section in the narrowest part of the strait is 6,251.8 square yards. The outflow, if accomplished in six hours and at a mean rate, would have a velocity of about 0.5 of a nautical mile an hour. This is the general average, from side to side, and from top to bottom of the channel, and includes the friction on the sides and bed; of course it is less than that given by our observations taken at stations in the axis of the stream; and our computed rate is also to be increased by *river* outflow.

"After we have enlarged the tidal capacities of the rivers and basins above the city to the extreme limits proposed, the average current in this strait on the ebb will be increased to 0.6 of a mile; and the maximum velocity of ordinary tidal currents in the thread of the stream

will be 1.2 nautical miles an hour. The current will still be feeble, compared with that of the deeper anchorage ground in most other harbors. In the forthcoming Report we may dwell upon this matter more critically, and show, by means of a comparative table, that Boston harbor, when contrasted with some other ports, may be said to be traversed by tidal drifts of a very feeble character."

The velocities here quoted were obtained from one set of observations made on July 26, 1860; to predicate conclusions upon such meager scientific data is at least open to criticism. A reference to the diagram (E, commissioners' report) shows that the maximum ebb velocity noted at this time was at the surface; the minimum, at a depth of 36 feet below the surface.

The commissioners, using six hours as the period of flow, obtained a general average velocity due to the outflow of the 40,000,000 cubic yards of tide water held in all of the tidal basins above East Boston of .5 of a nautical mile per hour, and say that, by enlarging the tidal capacities of the basins above East Boston to the "extreme limits" proposed, the average velocity will be increased to .6 of a mile, being an increase of .1 of a mile, and leaving the currents only "tidal drifts of a very feeble character."

We have in these quotations a statement of a tidal velocity based upon a single tidal observation; an average tidal velocity obtained by calculation; a statement that the calculated velocity is less than that observed, and the requirement that the velocity obtained by calculation is to be increased by river outflow presumably to make it agree with the velocity obtained by observation.

The tenth report of the commissioners (City Document, No. 50, 1866) contains a summing up of the studies made by them, a statement of facts and conclusions and a description of certain plans which the commission urges for the improvement of the upper harbor. In this report the commissioners say (page 6): "We may divide into two classes the tidal harbors of our coast under the titles of *Inlets* and *Arms of the Sea;* the former, occurring in alluvial regions, are usually barred by the action of the ocean waves; while the latter, occurring in rocky or less yielding shores, have a free access from the sea. Both of these classes are subject to interior obstructions from accumulations of sands or other deposits, and present in their sheltered portions similar characteristics; they differ in the amount of material supplied for shoal formations, but they agree in their dependence upon the working power of currents for the maintenance of their principal avenues. When these currents are absent, or feeble of action, tidal harbors are subject to a decline of depth from accumulations of material brought into them by waters from the land, or by the wear of their shores."

There is little or no evidence that Boston inner harbor has experienced any measurable decline in depth from this

cause; if its feeble currents were sufficient to cause such decline, changes much more marked than have so far been observed would have taken place.

On page 7: "We may divide into two classes the materials which are prone to encumber a channel, — the *rolling* and the *suspended*. The rolling materials, such as sands, are slowly transported from point to point, their rate of travel being in exceedingly small ratio to the velocity of the stream. Suspended matter, whether earthy or vegetable, is, on the other hand, carried forward with nearly the full velocity of the current in which it swims. Rolling material accumulates at the points where the alternate drifts, however strong, are equal and opposite, and also where the currents grow feeble. Suspended matter finds no resting place except when and where the stream slackens. In channels traversed by strong tidal currents, even when these alternate drifts are equal and opposite, muds are not apt to accumulate rapidly if the periods of slack water are of short duration. The suspended matter moves up or down the channel with each tide, finding no rest till it works into sheltered coves, or into the broken and more tardy drifts along shore. To keep the channel of a tidal harbor clear, then, of both of these classes of deposits, it is not only necessary that the current should have sufficient working power, but that the forces, considered as grouped for a tidal day, should have a *resultant*."

The shifting about of comparatively small quantities of sediment and light material does not in itself cause a general decline of depth; the transportation of material from one part of a harbor bed to another will result in the deepening of one place and the shoaling of another, but the impairment of the harbor as a whole does not follow from this process. The Harbor and Land Commission, so far as is known, has not been called upon or found it necessary to dredge any area in the harbor a second time to remove material which had accumulated since the first dredging of the area. In fact, the commission said, on page 8 of its special report (Senate Document, No. 303, May 1, 1895), that the total amount of dredging for purposes of deepening done in the upper harbor since 1874 was 5,252,495 cubic yards, and that "The channels so dredged maintain their depths, and it has not been necessary to redredge them except in two cases." The first case was a narrow channel near the dock of the Mystic River Corporation, and the engineer of the commission stated of this: "The dredged channel was narrow and at right angles to the current of the river; the material through which it was dredged was fine sand, and in a few years the banks of the excavation caved down and filled in the channel a number of feet." The other case was the reserved channel on the South Boston flats, where the dumping of dredged material made it necessary to redredge the area. The special commission itself says that it

has found traces of many causes, rather than well-defined effects; a "trace" of a cause is not the cause itself, and effects which are not "well-defined" cannot fairly be charged by engineering science, which is itself precise, to causes of which there are only traces.

In regard to the statement that "Rolling material accumulates at the points where the alternate drifts, however strong, are equal and opposite, and also where the currents grow feeble," if the velocity of the current is not sufficient to erode material from the bottom and banks of the main channels and there is no considerable amount of sediment washed in from the flats and shoal water areas forming the fringe of the harbor, there will be neither rolling material nor sediment to accumulate.

"Now, let us inquire under what circumstances the currents of a tidal harbor have a resultant. For the sake of separate discussion, we shall state three conditions, under which a resultant or scouring force naturally appears: —

"*First.* — When back water reinforces the ebb current, giving to it a predominance over the flood.

"*Second.* — When the paths of the ebb and flood currents differ in direction or in width.

"*Third.* — When the *acquired* velocities of the two currents are unequal at any point.

"The word back water is to be found in nearly all the reports on harbor improvements that have come to our knowledge, and it has been used with so much latitude that it will be necessary for us to define it strictly before we can proceed with this discussion. Back water is simply *land water*, — the fresh-water supply."

The commissioners then cite from a report on the tidal harbors of England: "in any place where the tides are felt, what can properly be called land waters or back waters, is only the overplus by which the water that passes or runs down in the ebb towards the sea exceeds the quantity of waters that passed or were forced up during the preceding flood" and then say: "The above extract accords with our views; it covers the whole meaning of the term back water, as we use it, and furnishes a correct measure of this element. If we desire only to know the speed or force of the river at any particular point, we should adopt the following rule: *the river current is half the difference between the observed inflow and outflow at equal heights of flood and ebb tide.*"

As to the *first* condition, it is my opinion that the Charles River water in this case has no resultant value measurable in its effect upon the harbor channels, except as it may tend to keep the narrow outlet channel of the river free from accumulations at the expense of the area immediately below Charlestown bridge and above the cross-section between Boston and East Boston, where such velocity as it may have acquired is immediately dissipated by expansion into the rapidly widening harbor area below.

In regard to the *second*, if the paths of the two currents are different, the resultant is as likely to be one damaging to the harbor as one tending to improve it; the path of an eroding flood current may lie in a portion of the harbor where an eroding or transporting ebb current may be entirely absent.

As to the *third* condition, where the resultant follows from the inequality between the "acquired velocities" of the ebb and flood currents, the "acquired velocity" is that maximum velocity which a current has after all the forces tending to create that current have accumulated and been brought into co-operative action. In a simple case, such as the flow of a considerable quantity of water through a long, straight channel of uniform cross-section, velocity and slope of surface will bear a constant relation to each other. Where a sudden widening of the surface and increase of depth of section take place, the slope of surface is flattened and the velocity diminished. No series of observations having any practical value have ever been made of the "acquired velocity" of either ebb or flood currents on the cross-section at the head of the harbor between Boston and East Boston (line 2 on map). The result of an inquiry in this direction is fully set forth in the following correspondence with the engineer of the Harbor and Land Commission: —

NEWTONVILLE, MASS., Jan. 2, 1902.

DEAR MR. HODGDON: — Referring to the map of Charles River at the bridges, Survey of August, September and October, 1882, accompanying annual report of Harbor and Land Commissioners for 1882, will you kindly inform me what velocities the figures on the arrows showing the current represent; whether surface or mean velocity in each case. Also, just what method was used in obtaining these velocities; form of floats used, and whether or not these velocities were in any way obtained from or checked by the observations for slope of river as noted by simultaneous readings on gauges located at the fourteen different stations mentioned on page 11 of that report. Also, whether from these observations and calculations any curves of velocity, from surface to bed, were calculated and plotted.

Kindly let me hear from you by early mail, and oblige,

Yours truly, PERCY M. BLAKE.

MR. FRANK W. HODGDON, *Chief Engineer, Harbor and Land Commission, Boston, Mass.*

BOARD OF HARBOR AND LAND COMMISSIONERS,
STATE HOUSE, BOSTON, Jan. 2, 1902.

PERCY M. BLAKE, Esq., *Newtonville, Mass.*

DEAR SIR: — The figures on the arrows on the plan of the survey of Charles river made in 1882 give the velocities in nautical miles per hour. These velocities were measured by a float consisting of a

tin can about 3 inches in diameter and 5 feet long, weighted so that it floated vertically in the water with its top practically level with the surface. At the top was attached a light line tagged off in feet and the float was allowed to go with the current and the distance travelled in a given time was measured on the tagged line. In addition to this free floats were used, the times of their passage by the lines of the bridges being noted. So far as I know the tidal observations made at the fourteen different stations were not used in calculating the velocities except in a general way. . . .

Very truly, FRANK W. HODGDON,
Engineer.

On this subject the commissioners say, on page 18 of their final report: "From our own observations upon tidal streams, where the influence of the slope of the bed is eliminated, we have perceived that the head accumulates during the time that is *consumed* by the current in acquiring velocity; but after this period of time (which we may also represent by *distance*) the head becomes constant and even declines, and is finally in great measure lost in horizontal motion. In the same way we should explain the action of river freshets. In the upper reaches of the stream, motion is *being acquired*, but not fast enough to consume the supply; in the lower reaches, nearly the full speed requisite to consume the unusual supply is attained, and the existing elevation is only that amount due to local friction. Most of the phenomena connected with the elevation of running water are effects of its inertia. Friction (strictly speaking) is but a small element of retard to the flow."

The special commission placed much stress upon the interference with the ebb tide velocity caused by the bridges across the outlet of the Charles River, and the Harbor and Land Commission has deprecated the existence of these structures on the same ground. It has been claimed by both of these commissions that the "acquired velocity" of this outflow is largely destroyed by the obstructions; but the value, if there be any, of the velocity destroyed is lost only to that limited section of the channel lying above Charlestown bridge.

The bridges do not prevent the flow of the tidal prism and land water through the river outlet, but simply temporarily interfere with the slope of the water surface. The expansion of the stream below this lower bridge is immediate, and the velocity due to an uninterrupted outflow of tidal and land water would be diminished with equal promptness as the channel expands, if the slope of the water surface from Charles River bridge to the West Boston bridge were uniform.

It is my opinion that the ebb current has as much acquired velocity on the upper cross-section of the harbor between Boston and East Boston (line 2 on map), with the present bridges in place, as it would have were these bridges wholly removed from the channel of the stream.

The ebb flow from the present Charles basin now enters the main channel at an angle of 90°, and meets the ebb current coming from the Mystic and Chelsea Creek basins at an angle of about 130°; any "acquired" velocity which the outflow from the Charles River basin at any time had was greatly reduced by its conflict with the Mystic ebb current and by being compelled to make an abrupt turn to the right in getting into line for passage through the channel between Boston and East Boston.

It is my opinion that the ebb flow from the Charles River basin never added to the strength of the ebb current in scouring power derived from a velocity acquired above its confluence with the ebb flow from the Mystic and Chelsea Creek basins.

The rule which the commissioners lay down for finding the river current, namely, taking "half the difference between the observed inflow and outflow at equal heights of flood and ebb tide," is hardly capable of application with any precision, and at the best is only approximate. I have already shown the value of the river current.

On page 9 the commissioners say: "The value of back water is enhanced by mingling with tidal drifts. For instance, if the river current, strictly speaking, has a velocity of but three-tenths of a mile per hour, it is by itself insufficient in power to roll a grain of sand upon the bottom, but united to a tidal current of the same velocity, it gains this power, it increases the rate of the outflow to six-tenths of a mile, and wholly destroys the inflow, so that the grain of sand will finally be carried into the ocean. Suspended matter brought down by a river would be deposited, on reaching a broader and deeper basin, where the river current slackens, were it not that the tidal drifts keep it moving till it is carried to sea or disposed of in the coves or angles on either side of the channel ways. We do not by any means concur with those British writers who regard the natural tidal drifts as inoperative; we give to these drifts, especially in such a harbor as Boston, which is fed by feeble land streams, a very important place."

Professor Mitchell had previously stated that no observations, however nice, could determine those factors, and in my own experience I have tried to determine them, but have been unable to do so.

On page 12, under the head of "Acquired Velocities," the commissioners say: "Were it not for the waves of the sea, the ebb current of sandy harbors would have the power to carry material some distance

from the coast and deposit it gradually over so large an area of deep water that it would be essentially lost. But waves not only break up the ebb suddenly, so as to compel it to throw down at once large masses of material at the very entrance of the harbor, but they frequently force the sand of the coast into the harbor itself, and fill up the basins."

On page 20, under the head of "Basins and Reservoirs," the commissioners say: "If a river or tidal stream flows into a broad basin where its velocity is lessened, a deposit of its sediments takes place; it is more or less purged of its muds and foreign matter of all kinds," and on page 21: "A reservoir by accumulating and discharging large bodies of tide and back water, quickens the drifts through the channels below, and maintains through the main arteries of the harbor a good depth of water, not only by positive action in the scour of the bottom, but also by denying to the suspended muds which escape from the reservoir, any opportunity to settle till they find their way—as in course of time they will—into the less agitated coves and shelters along shore."

On page 22, when speaking of the advantage in a reservoir situated above a seaport, the commissioners say: "It is a grand receptacle for the sedimentary deposits of land streams, and the resting place for a portion of the material scoured from the harbor channels."

Again, on page 25: "In the case of a *tidal reservoir* (strictly such), a loss of width cannot be replaced by a deepening below the tidal prism; an encroachment upon the superficial area involves a loss of tide water, by which the third advantage mentioned is diminished. The best form for a *tidal* reservoir would, perhaps, be the circular; but for a river, and a tidal river, where the downward current is to be relieved of sediments, the *estuary form*, for the upper part of the basin, would be the most desirable, because, as we shall hereafter have occasion to explain, a more sudden expansion of the river would not add to the advantages."

Other quotations of value in this case are on page 31: "Near the time of low water, when Boston harbor is but little agitated by currents, there flows from the South Bay and other shallow lagoons, a number of muddy brooks, adding their contributions to the extension of marginal flats. These brooks are generally called *guzzles*. The remedy for the ill effects of these low-water deposits from guzzles is obvious; *we have but to deepen and widen the low-water portion of them and to maintain them thus improved.* In this way not only will the velocities be lessened, and sediments neither be acquired nor retained, but, by removing friction and adding capacity, the delay of the low-water epoch will also be shortened, and these muddy brooks or guzzles, to which we have referred, will cease to exist or be rendered less injurious. We repeat with confidence the statement that no other than good effects can result from the artificial deepening of the low-water channel of a basin or feeder above a harbor; and we may even go further, and assert that, under special circumstances, a foot of deepening below the low-water plane may be *locally* more than equivalent compensation for a foot of tidal prism lost at another point."

Such marginal flats as now exist in the proposed basin will not, after the dam is constructed, be drained on every ebb tide and the material eroded from them carried by the ebb flow into the harbor channels. By maintaining a constant water level over these flats any source of deposits in the harbor channels, in this basin, will be cut off.

On page 32: "That the tidal reservoir is of no value to the channel *above it* we have often intimated in our Reports, and in the case of Boston Harbor, we have shown that the Main Channel of the upper Harbor gains no advantage but, on the contrary, is injured by the expansion of the tides over the South Boston and Bird Island Flats; although we have steadily adhered to the opinion that the lower Harbor could not afford to lose the advantage of any portion of the tidal capacity above."

It would appear from the above quotation that the commission took the view that the situation then under discussion required it to take a midway position, there being on the one hand the urgent necessity and demand for encroachment upon the South Boston flats and the maintenance of the main channel of the upper harbor, and on the other hand the risk of impairing the channel ways of the lower or outer harbor. The commissioners had previously, in 1864, projected a breakwater to extend from Governor's Island north-westerly across Bird Island flats to a point within 1,000 feet of the East Boston docks, with a view to preventing the expansion of the tides over the Bird Island flats and shoals lying east of East Boston. The harbor line proposed for the reclamation of the South Boston flats and the projected breakwater if constructed would have formed training lines for the currents of the main ship channel, and the projected breakwater would have prevented the infilling of this ship channel with material likely to be washed into it from the Bird Island flats and the shoals north of Governor's Island.

On page 33 of this report the commissioners say: "In the Main Channel of the upper Harbor of Boston, the flood current, just above the Castle Island contraction, gathers strength after the flats are covered; so that part of the material removed from the contraction below is probably cast down in the basin. In advocating the interest of the lower Harbor, we have insisted that no diminution of tidal reservoir should be suffered above; and therefore, in our Reports, we have urged the closing in of the South Boston Flats only with the condition that an equal reservoir should be opened above the city. We wish to remove the foot of the flood-inclined plane to a point above, where deposits would be less detrimental."

It is evident that the construction of a tidal reservoir above the city having a tidal volume of 365,000,000 cubic feet was totally impracticable; 365,000,000 cubic feet is equivalent to a little more than 13,500,000 cubic yards, to dredge which, at 20 cents per cubic yard, would cost $2,700,000, the annual interest on which at 3 per cent. would be $81,000. This quantity, 13,500,000 cubic yards, is four times the quantity dredged by the Commonwealth since 1873, or in twenty-nine years, from the upper harbor.

On page 34: "The destruction of tidal reservoirs which fulfill the conditions stated in D,* is a step towards the destruction of the harbor. No proposition to reclaim basins, flats, or salt meadows, should be entertained till the measure of their usefulness in the harbor has been

* D. — "The distance at which a reservoir may be useful is limited by that at which, by communicated activity, it can quicken the currents in the harbor below, without deranging their epochs; and the depth of any reservoir has a usefulness dependent upon the same limitation."

investigated; and no expense for deepening or enlarging such tidal receptacles should be incurred till, from the best data, a prediction of its probable advantage to the harbor can be made. In nature we scarcely find tidal reservoirs fulfilling exactly the conditions stated in D; * but in all good harbors there are close approximations to them. Most reservoirs can be improved artificially, and in some harbors useless reservoirs may be found."

On page 35: "*Decline of Tidal Reservoirs, and its Causes.* — From the very nature of tidal reservoirs, receiving as they do, the sediments both of the downward and upward currents, it is to be expected that they will naturally suffer a decrease of depth, if not also of area. With this decrease there will be an increased disposition of the drifts to make their deposits farther and farther seaward. The same effect will follow if a reservoir is encroached upon by diking in meadows; by wharfing; by the construction of bridges; and by the choking up of lateral receptacles. To these causes, among others, may be assigned the deposit of mud which of late years has taken place in the Main Channel of Boston harbor."

From this statement it appears that, *without artificial improvement*, the tidal basin of the river, by the accumulation of sediments brought into it not only by the land flow but by the flood current, would in time decline and decrease in value, if it had any value in the first place.

"The consequences of a diminution of a tidal reservoir, both in depth and area, are twofold: First, the river does not slacken its velocity so much as formerly in traversing the basin, so that it reaches the avenue below without being so completely purified of its sediments. Second, the avenue itself is less taxed than formerly, having to supply and drain less tide water; its currents, more especially the *outflows*, become more superficial, because flowing from a higher plane and with less pressure; the consequence is, that slack spaces occur along the bed and at the borders of the channel, into which muds quietly settle."

On page 36: "We perceive then, that, with the decline of a reservoir situated near the mouth of a tidal river, the channel below suffers a double injury. Not only does this channel fall into partial disuse as a tidal track, and therefore become subject to encroachment from local causes; but it is called upon to receive a portion of the river muds, that have failed to find rest in the reduced basin above."

From sheets accompanying the Harbor and Land Commissioners' report of 1894 on the proposed dam I have taken the facts as to shoaling and deepening in the upper part of the harbor. Those sheets contain, in the form of small squares and red and black figures, areas where deepening has taken place and areas where shoaling has taken place. The condition of that portion of the harbor above the line of the East Boston south ferry in 1892, as compared with its condition in 1835, shows, during the period of fifty-seven years between those years, net results of shoaling of 466,791 cubic yards, or an average per year of

* See note on page 222.

8,189 cubic yards, which, at 20 cents per cubic yard (a fair price for dredging the kind of material forming these deposits), would require an expenditure of $1,637.80 per year. But, taking the same plans and studying the changes due to the shifting of material which had taken place in the whole of the upper harbor above the seaward outlets of that harbor, it appears that from 1835 to 1861 (twenty-six years) there had been a net *deepening* above Anchorage Shoal of 503,240 cubic yards; and from 1861 to 1892 (thirty-one years) there had been a net *shoaling* over the same area of 692,562 cubic yards; making a net *shoaling* from 1835 to 1892 (in fifty-seven years) of 189,322 cubic yards, or at the rate of 3,322 cubic yards per year, which, at 20 cents per cubic yard for dredging, would represent an annual expense of $664.40.

From 1861 to 1892 (a period of thirty-one years) the net *deepening* between Anchorage Shoal and the seaward outlets of the harbor (bounded on the map by lines 3, 4 and 5) was 600,745 cubic yards, or at the rate of 19,380 cubic yards per year, which, at 20 cents per cubic yard, would cost $3,876 per year,—a value greater by $3,211.60 than the cost of dredging the net shoaling taking place between 1835 and 1892 in that portion of the harbor above Anchorage Shoal.

In part second of this report the commissioners say (page 49), when speaking of Boston harbor: "Here is a fine anchorage-ground, protected from wind and sea, with two deep entrances from an outer roadstead; and these entrances, as well as the roadstead itself, are kept free by tidal currents, especially, without aid from back waters."

On page 50: "The upper Harbor — the portion above Castle Island — is too near the head of tide water to be traversed by a great volume of ebb and flood; the evidences, therefore, of strong running forces are only to be met with at its contractions. It is, however, a receptacle of both tidal and river waters, and the latter bears in amount a larger ratio to the former in this than in any of the other portions of the Harbor that we have named; — yet here it is small, — so small that without the co-operation of tide water, it could not maintain a navigable channel to the sea. The Main Channel of the upper Harbor of Boston is chiefly dependent for its depth and width upon its service as the avenue of supply and drainage for the basins of the Charles and Mystic rivers and Chelsea Creek. Were these reservoirs closed, the larger part of this main artery would, in course of time, cease to exist, for it is but the trench dug through the yielding bed of the Harbor by the passage, to and fro, of the river and tidal waters. The history of the upper harbor shows that this main channel has declined as the basins or natural reservoirs above have decreased, — not in due proportion as yet, for the full effects of the encroachments are not developed. Indeed, we may reasonably be surprised to find these effects already traceable; and we should be prepared to see them

increase rather than decline in their rate of development. The simple fact that the reservoirs have been artificially diminished, implies a quickening of the river current passing through them, and a lessening of the flowage of tide water through the avenue below. Again, the fact that the encroachments have been made upon the widths and not upon the lengths of these reservoirs, so as to make their forms more eccentric than originally, justifies the opinion that from this cause the tidal currents of the reservoirs themselves suffer less check than formerly, while those of the Main Channel are diminished. A quickening of the currents in the reservoirs diminishes the sedimentary deposits therein; and a diminution of currents in the Main Channel, increases the tendency to deposits in this avenue. The encroachments upon the river basins have, therefore, been a double source of injury."

As to the opinion that were the tidal basins closed, the larger part of the main channel would in course of time cease to exist, it seems hardly necessary to offer a criticism. At the time the commissioners made this report they had discovered no "well-defined effects" suggesting such a calamity, notwithstanding that a large portion of the tidal prism of the Charles basin had been removed by filling above Craigie bridge. The commissioners say that "we may reasonably be surprised to find these effects already traceable;" in view of the fact that such great encroachments had already been made upon the Charles basin, this statement is indeed remarkable, if the theories and conclusions of the commission were correct.

On page 51: "At a station in the mouth of Charles River, about a quarter of a mile to westward of the United States dry dock, from observations extending through an entire tidal day, the ratio of inflow to outflow was found to be as 8 : 10; and the mean hourly velocity of the river current five-hundredths of a mile."

The ratio of inflow to outflow of 8 : 10 was based upon the most meager information. A determination of fact in this case could only be approximated from the most complex, prolonged and scientific measurements. I have already shown the average velocity in the current due to the land water.

On page 52: "A current of .05 miles per hour is too small for any corrosive action upon the bed or banks of a stream. According to Du Buat, it requires more than three times this velocity 'to remove clay fit for pottery,' and we may class the stiff clays which form the natural bed of the Charles River under this head. The lighter muds, vegetable earths, and sewerage, could scarcely be suspended by so feeble a current; yet, united with tidal drifts, this river water becomes an element of great importance, giving to the outflow a duration one hour in excess of the inflow."

On page 52 the commission state frankly that a current of .05 of a mile per hour is too small to erode material, especially the stiff clays which the commissioners state form the natural bed of the Charles River. Du Buat's experiments are far from conclusive in regard to the eroding power of a flow of water, made, as they were, in a small artificial channel, 18 inches wide and inclined 1 in 200, in the bottom of which was placed by hand certain earths and gravels. The actual condition of materials *in situ* in the bed of a stream or channel is very different from any condition which can be produced by removing such materials from natural locations and placing them by hand in a small trough or artificial channel.

On page 53: "We are brought to the conclusion that *Boston Harbor is mainly dependent upon the volume of tide water for its deep channelways;* but that its back water, *although scantily supplied is an important element.*"

The practical importance of this back or land water is measured by the proportions it bears to the tidal prism in the Charles basin; these proportions have been previously shown by the calculations made for this report to be in the month of March, 7.35 per cent.; in May, 2.87 per cent.; in July, August and September, from .43 of 1 per cent. to .67 of 1 per cent.

On page 54 of this report the commissioners further say: "At the junction of the two rivers (Charles and Mystic), the advantage gained by the ebb over the flood, to which we have referred is in a measure retained; the duration of ebb exceeds that of flood by 2.08, but the ebb *in force* has less than one hour's advantage over the flood. It will be observed also that the outflow at Station 4 continues too long after the tide has commenced to rise, and that the inflow is 1.20 behind the epoch of low water. What we have said of the epochs of the slack currents also applies in a more remarkable degree to those of maximum flow. The ebb at the junction of the two rivers does not acquire its greatest rate of flow till one hour before low water, so that when the tidal current at the mouth of the Harbor has commenced to run flood, that of the Main Channel of the upper Harbor has a considerable velocity in the direction of ebb. The upper Harbor is hence a scene of conflict, or at best that of opposing forces, neutralizing each other at time of low water."

On page 55: "*The ebb current does not slacken sufficiently in the basins above the city. The eccentric form of these reservoirs and their small capacity causes them in great measure to fail as adequate tidal reservoirs and as expansion basins. There are causes which prevent the free and timely exit of the ebb from these basins.* In the Mystic Estuary the natural accumulations of mud and the artificial encroachments in the way of wharf building and reclaiming of water spaces, have reduced the width of the basin, so that the ebb from above does not now expend itself sufficiently to slacken, especially near the time of low water. In the Charles, the reclaiming of the Back Bay, and other smaller encroachments, have caused a quickening of the ebb from above, and increased the ratio of river to tide water, so that as a sediment basin it cannot be as useful as formerly."

On page 56: "There is no want of capacity in the channel of the Harbor below the river mouths. The avenue at its narrowest point between Boston and East Boston, is sufficiently ample to discharge a much larger quantity of water than it now does: . . . *the size and depth*, of both the Charles and Mystic basins, could be doubled without overtaxing the avenue between the cities below. The velocities of ebb and flood currents rarely exceed one mile per hour in this avenue, so that these drifts could be considerably increased without inconvenience to vessels. To furnish some idea of the velocities of currents in localities much frequented by commerce, the following comparisons are taken from our Report on New York Harbor.

LOCALITIES.	Rise and Fall of Tide. (Feet.)	Velocity of Currents. (Miles per Hour.)	Remarks.
Between Boston and East Boston,	10	1.0	
Nantasket Roads, . . .	9¾	1.3	From observations at half ebb.
Hudson at New York, . . .	4.3	2.3	
East River at New York, . .	4.3	3.0	
East River at Hell Gate, . .	4.4	8.5	
Kill Von Kull, ...	4.3	2.1	

"The currents of Boston Harbor, it may be seen, are very sluggish, considering the great rise and fall of the tide; and the very fact that they are so indicates the insignificance of the reservoirs above."

On pages 57 and 58: "In our Fourth Report, page 10, occurs the following statement:—'The too sudden expansion of the ebb stream (the compound of the Mystic and Charles River waters), after passing the strait between the city and East Boston, is a grand source of mischief; for the power of this main stream is exhausted by the very act of divergence, and its margins collide with other streams which flow into the Harbor by lateral channels.' The 'expansion' that we referred to in the cited paragraph is precisely what we desire to have effected *above* the city to give the mud an opportunity to settle. . . . Our idea of the remedy is to increase the basins *above*, to check the activity of the currents in the river basins, and to quicken those in the Harbor."

The proposition in this quotation is paradoxical, as it is evidently impracticable by expansion ABOVE the strait to offset the expansion below the strait; in other words, an increase of the basin above will not prevent the divergence below which the commissioners emphasize.

The commissioners, on page 60, say further: "In the few pages immediately preceding we have laid down general principles, and illustrated them by striking examples, in which the relation of cause and effect is simple, direct, and obvious, reserving the application of them to our subject, because, in Boston Harbor, we discover *traces* of many causes, rather than *well-defined effects*."

It is not necessary to comment upon these statements and conclusions of the special commission. The proposition to close in the South Boston flats was based upon an impracticable improvement, namely, the opening of an equal reservoir above the city.

It is interesting to note the views of Maj. Charles W. Raymond, Corps of Engineers, U.S.A., whose paper, presented to the Society of

Arts on Jan. 8, 1885, attracted much attention. Major Raymond then said: "From the very nature of a tidal reservoir it must gradually fill up and lose its efficiency; from the very nature of a tidal channel through a bed of drift it must gradually lose its depth under the influence of its own currents. What then is to be done? I answer that the efforts of nature must be assisted, and her work completed by the use of the dredge. This is much more practicable now than it was when the United States Commissioners published their reports, for steam dredging machinery has since been greatly improved, and the cost of dredging has been much reduced. This is the price we must pay for our injurious inland improvements. . . . It is evident that a great tidal harbor, like that upon which the commercial prosperity of the city of Boston depends, cannot safely be abandoned to the action of natural forces, or to the operations of private enterprise which are more likely to result in injury than in benefit. If such a harbor is to be preserved from deterioration, it must be the subject of continuous and elaborate study, and all constructions connected with it must be under intelligent control. More than this, as the city grows, as its commerce develops, as the ships carrying our ocean freights increase in size, something more is needed than the mere preservation of our existing facilities. The harbor must be *improved*, if we would preserve the relation between its capacity and the demands upon it."

Major Raymond's view was forward rather than backward and in the seventeen years which have elapsed since that time the rapid growth of the port of Boston has demanded a still broader view of the situation; this broader view holds firmly to the value of the navigable channels of the port while recognizing as of great importance the land growth and demand for increased shore facilities.

Respectfully submitted, PERCY M. BLAKE,
Civil Engineer.

NEWTONVILLE, MASS., Feb. 15, 1902.

It is my opinion that the construction and maintenance of the proposed Charles River basin will actually benefit the upper harbor, and I believe, if all the tidal basins above the upper harbor were closed to tidal action, the harbor would benefit thereby. My reasons for the opinion are the following simple facts: —

The upper harbor is itself a basin, fed mainly by water from the Atlantic Ocean, secondarily, by land waters flowing into it through the Charles and Mystic river channels.

The shape of this harbor basin is such that upon the incoming flood tide the sea water, after passing through the seaward entrances, spreads itself out laterally in very feeble currents, — none stronger than one mile per hour. At the upper end of the basin the flood current is retarded, then slightly concentrated and accelerated as it passes through the comparatively narrow channel between Boston and East Boston.

The only sediment which is now eroded from the bottom by the flood currents is that coming from the northerly and shoal side of the harbor, and this is forced shoreward on to

the flats. This sediment is small in quantity, and but very little if any of it is carried toward the head of the harbor. What little may be carried in that direction would find a feebler power for transportation if the flood current were prevented from going into the tidal basins of the Charles and Mystic rivers.

The Mystic River water brings into the basin on the ebb flow an exceedingly small amount of sediment, and the Charles River brings into the Charles basin but a very small amount. The ebb flow from the Charles basin probably carries back into the main channel a small or measurable amount of sediment washed from its flats as the tide recedes.

The excluding from the harbor basin of the ebb flows from these river basins would inevitably result, first, in checking the velocity of the flood current as it approaches the upper and narrow part of the main channel between Boston and East Boston; and, second, in withholding from the harbor channel any outflowing sediment which the ebb currents now gather from the flats in the river basins. There would be no complexity or disturbance of currents in the vicinity of the Navy Yard as at present. The whole effect of the exclusion of these tidal prisms from the river basins would be beneficial to the upper channels of the harbor, and would greatly reduce if not wholly remove any power in either current to erode the bottom and sides of this channel and the adjacent shoaler bottom.

Hearing adjourned to Monday, March 3, 1902, at 10 A.M.

EIGHTH HEARING.

RAILROAD COMMISSIONERS' OFFICE,
BOSTON, March 3, 1902.

The hearing was begun at 10.20 A.M., Chairman Pritchett presiding. All members of the committee present.

TESTIMONY OF PERCY M. BLAKE — *resumed.*

Q. (by Mr. MATTHEWS). Mr. Blake, calling your attention to the large map which you presented on Friday, I will ask you if you can state the total fall of Charles River between the upper dam at Newton and the head of tide water at the Watertown dam. A. Approximately 90 feet.

Q. And to what extent is that fall taken up by the dams and basins between those two points? A. As near as can be ascertained, all but about 10 feet of that fall is taken up by the structures or dams on the stream, the tail water in each case being nearly on the level of the overflow of the dam next below. This section of the river is practically one continuous settling basin, subdivided by the dams.

Q. That is, about 80 feet of the 90 feet is taken up by dams? A. Yes.

Q. How many of those dams and basins are there between the upper dam at Newton and the lower dam at Watertown? A. There are 8.

Q. I understand you to say that each one backed the river up nearly to the foot of the next dam above? A. Practically, yes.

Q. So that practically there is a continuous settling basin between the two points I have named? A. Yes, sir.

Q. Now, what is the condition of the river with regard to current above the upper dam at Newton? A. Above the upper dam at Newton Upper Falls, shown on the extreme left hand of the map, there is little or no fall for a distance of 14 miles. Above what is known as Kendrick Street, above Newton Upper Falls, the river runs through meadow lands so flat that there is only fall enough to just keep the water in motion, and in places the velocity is so small that excepting in times of freshets it is not observable. That area forms a settling basin for all the material that comes from above, and also forms a regulator of the flow of the

water in the river below that point, so that the actual flow of water in the Charles River below the dam at Newton Upper Falls is as a rule more constant than the flow in any other similar river in this part of the State.

Q. You say that that condition of meadows exists for about 14 miles above the upper dam at Newton? A. About 14 miles before the first appreciable fall, with any activity in the current, is met.

Q. What is the character of the stream above that point? A. It is a very sluggish river all the way up. There are a few small dams across the river in the towns of Millis, Medway and Bellingham, and a few country saw mills or dams above that point. Between Bellingham and Newton Upper Falls the valley forming the bed of the stream is practically one settling basin. The water which comes out of this large settling basin area at Newton Upper Falls is practically free from sediment, you may say almost entirely free from sediment, and contains as the only foreign element a high degree of color, which is solely due to a vegetable infusion coming from the grasses in the meadows where the water stands for a long time; it is like an infusion of tea, herbs or any other vegetable coloring matter.

Q. Is that coloring due to any material held in suspense? A. No, sir; the coloring matter is in a limited way a chemical combination. It is not a mechanical solution, as a coloring extract is hardly held in mechanical solution; it becomes part of the water, practically. Bleaching will remove a little of it; ordinary sedimentation will not affect color.

Q. How does it compare in color with the Sudbury water or the present Nashua supply? A. Taking the present Nashua supply above the point where it receives its first treatment, the Charles River water will be a little more highly colored in the average year, and the color is a little more persistent; that is, it will remain a little longer, and is not so readily reduced and washed out by flood waters, because those flood waters are themselves retained in the flat reservoirs. In the case of the Nashua River the watershed is more hilly and cleaner, and, while the waters of the streams forming the Nashua River are highly colored at some seasons, at others they are comparatively white and clean.

Q. Now, coming down the river to the Watertown dam, what do you say about the character of the water as it flows into the tidal basin? A. I have characterized that in my statement as clean, fresh water. It is not pure water in a

sanitary sense, but it is in that sense clean water. It is wholly fresh water at that point, of course, as no sea water gets into it. As it flows out of the basin above Newton Upper Falls it is a remarkably clean water, although quite highly colored. The color is transparent, so that you can read the lines on a newspaper through a gallon jar of the water as clearly as you can through spring water. It is at times, between Newton Upper Falls and Riverside, rendered a little turbid by street wash and some wash from gravel banks. That all disappears as the water traverses the bed between Newton Lower Falls and the first dam at Waltham, between which points there is another comparatively large settling basin. Below the first dam in Waltham and the dam in Watertown the water is turbid only after excessive rains, and that is due to street wash. There is some manufacturing waste turned into the stream, but between those dams and the lower part of the river the current is sufficiently active to thoroughly mix it with the water. As it passes over the lower Watertown dam, the river water, in my opinion, is a clean water, while not sufficiently pure for domestic supply.

Q. You mean not good enough to drink? A. Yes; not good enough to drink.

Q. What is its condition with regard to sediment? A. As it passes over the lower Watertown dam, it is remarkably free from sediment. I have taken pains to look at that dam on two freshet occasions, — not the one just passed, but on other occasions, — and I found the turbidity of the water as it then passed over the Watertown dam hardly noticeable.

Q. And that was in times of freshet? A. After a heavy rainfall in dry weather, when there was more turbidity than at this time of the year.

Q. What is your opinion concerning the Charles River as a silt-bearing stream? What is its capacity for carrying matter in suspense down into that basin? A. The Charles River as it passes over the lower Watertown dam does not convey into the basin below any measurable amount of sediment. It changes its character in that respect, however, after passing the Watertown dam. At low tide, when there is a large volume of fresh water flowing in the river channel, some erosion of the bank and bed of the stream takes place below the Watertown dam. There are further down, below the Captain's Island playground and on either side of the basin, certain flats which are soft enough to be eroded, mainly through the tidal "guzzles" to which I referred in

my statement. The stream does not bring sediment into the basin in measurable quantities as it passes over the Watertown dam; but at low tide, by the time the current flows by Craigie bridge it does bear some material which it has eroded from the low-water channels and side shoals in the basin.

Q. If I understand you, then, practically all the matter which the Charles River, as it flows out through Craigie bridge, brings down, comes from that portion of its length which is below the Watertown dam? A. Yes, sir.

Q. Is that action of the river and the tidal gullies or guzzles at low tide perceptible to the eye as you walk along the wharves or flats below low water? A. Very perceptible; they can be seen from either side of the river, at proper stages of the tide.

Q. You mean from away across the river? A. Yes, by the discoloration that these lateral streams produce in the main body as they come into it. They produce the same visual effect that a discharge from one of the storm overflows produces.

Q. If you row up through the river at dead low tide through the narrow channel which is left, what is the condition of the water in these lateral gullies that you meet every few yards, or few hundred feet, draining into the main channel, with reference to sediment? A. I cannot answer that from observations made by myself, but from the bridges which I have walked out on to, to look at that condition, I should say that at dead low tide the lateral inflow would be very largely over; but at half tide or two-thirds down, before the water flowing in laterally had all been exhausted, it is very noticeable.

Q. You can see that discoloration in the water either from the bridge or bank, or both? A. Yes, sir; at the right stage of tide, — coming in on diagonal lines.

Q. What data did you use, Mr. Blake, in coloring certain sections, certain portions, of this map pink? A. In part the Coast Survey map of 1857, scale 1 in 40,000; the legend in the upper left-hand corner says that the hydrography was completed in 1853. The data regarding areas reclaimed and amount of filling done, on page 6 in my report, were obtained from that map. The areas shaded pink on the large map are the areas which have been reclaimed since 1795.

Q. What sources of information did you use in getting at the filling that took place between 1795 and 1853, when this government survey was made? A. I had no line of demarcation between the two. The lines shown on the map of

1857 are not shown on here, but the areas shown on the map of 1857 are included in the larger areas shaded pink.

Q. What authorities did you use in getting at the original high-water mark as shown on your large map? A. The original high-water mark shown on the large map was obtained from documents prepared by the city of Boston, and published in certain reports issued by the city engineer's department.

Q. The calculations of areas filled that you have given in your written report are the lands that have been filled since 1853? A. Yes, sir; and so stated in my report.

Q. But the map shows, shaded in pink, not only lands filled since 1853, but, so far as you could ascertain, the tidal flats that were filled before that date? A. Yes, sir.

Q. And for that work you used the best data you could obtain? A. Yes, sir; I did.

Q. Particularly the official reports of the city of Boston? A. I did; yes, sir.

Q. (by Mr. MATTHEWS). Now, one or two other questions about this map. I see that you have at various cross-sections of the harbor, the figures 2, 3 and 4. Number 1, I suppose, is Craigie bridge, is it not? A. Yes, sir.

Q. Although not so numbered on the map? A. There was a name for that, so I gave it no number.

Q. I notice you have a solid line around Bird Island flats, enclosing a space indicated "Proposed anchorage pier;" that solid line does not yet indicate anything assented to by the War Department, but is something projected, is it not? A. Something projected, and authorized by the act of 1901, I think. It is indicated in the report of the Harbor and Land Commission for 1900.

Q. It is not a line that is comparable to similar solid lines on the map, as indicating action on the part of the United States government? A. No, sir.

Q. Now, Mr. Blake, calling your attention to the plans, elevations and details for the proposed dam that you submitted at the last hearing, I will ask you as to whether you consulted the plans or sketches prepared by the engineer of the State Board of Health for the proposition of 1894? A. Yes, I had available the studies which were made for that dam as reported in 1894? I made a requisition for them, and they kindly allowed me to examine them.

Q. And would you state to the committee, in a general way, the particulars in which this dam which you propose differs from the type of structure that was proposed by the State Board of Health in 1894, beginning at the left hand —

beginning with the lock. Do you remember the difference, if any, in the dimensions of the lock proposed by you, and that proposed by Mr. Stearns? A. The lock is of the same width as proposed in 1894. Its bottom is placed 2 feet lower. Its length is increased. The width of the top of the dam, as I have laid it out, is 60 feet. The plan of 1894 called for a width of 100 feet.

Q. For the whole structure? A. For the whole structure, — a finished width on top of 100 feet.

Q. So that your dam, as a whole, has a less width than the proposed dam of 1894? A. It is narrower on the top as proposed for the two upper locations, as in such a case it might have a rather limited use. Instead of being a highway for promiscuous travel, it might be devoted to a semipublic use, with car tracks excluded.

Q. You say the lock you propose is 2 feet lower than the plan proposed in 1894? A. Yes, sir.

Q. Isn't it a third longer? A. Not the effective structure. So far as the effectiveness of the lock goes it is practically the same thing.

Q. Your lock is 400 feet clear inside, is it not? A. Three hundred and fifty-six feet between the gates. The regulating ports, as I have laid them out, are of somewhat greater capacity, and the sill of those ports is placed at elevation 3 feet below mean low water. The design of 1894 placed those sills at mean low water.

Q. Your sills for regulating ports are 3 feet lower than those proposed by the Board of Health? A. Yes, sir, they are; and the ports themselves are carried straight up. In the study of 1894 the ports were conduits or covered sluiceways running through the dam.

Q. What would be the discharging areas of those ports above mean low water, as compared with the plan of the Board of Health? A. The effective discharge area of those ports would be about 30 per cent. greater.

Q. I am not asking you to criticise that plan, but calling your attention to what the differences were between the two plans. You mentioned the figure 528 as the discharging area of your port; I am right, am I not? A. Yes, sir; you are right.

Q. Now, what was the comparative figure for the proposed dam of 1894, — it was 360, wasn't it? A. Very nearly 400, I think, after allowing for the eccentricities of shape.

Q. That is where you get your increase of about 30 per cent. you spoke of a moment ago? A. Yes.

Q. Now, as to the tidal sluices, what is the difference between your plan and the plan proposed by the State Board of Health in that regard? A. There were no tidal sluices proposed in the study of 1894 by the State Board of Health; they have been added to this plan at request of counsel, and not because I consider them necessary.

Q. I understood you to say that, in your judgment as an engineer, those sluices are unnecessary? A. Yes, sir.

Q. As to the cost, how does this proposition of yours compare with the study of 1894? A. If you will allow me — there is another difference which you have not touched upon. The wasteway sluices shown on this plan, which I have submitted, were not included in the study of 1894.

Q. That is, that plan provided for no wasteway? A. No wasteway of this character. These wasteway sluices will afford a water way of 100 feet horizontally, with sills placed at elevation 5, which is 3 feet below the elevation of the water proposed to be maintained in the basin. They will act as a safety valve; if the regulating ports afford an insufficient opening, these sluiceways will provide an outlet for the basin. The sluice gates may be of the Stoney, counter-balanced type, modified to fit this case, and would require but little power in operation.

Q. Have you covered the structural differences between your plan and that of 1894? A. I think so, except so far as the details attending these variations would affect the structure itself. I have provided in the plan for filling and emptying the lock in the manner suggested by the study of 1894. That is on the extreme left of the blue-print.

Q. How does the cost of your structure compare with the structure proposed by the State Board of Health? A. The structure of the State Board of Health, as I remember, was to cost about $660,000 for a top width of about 100 feet. The estimate of this structure, exclusive of the tidal sluices, if located at a point selected by the commission of 1894, which is line *B* on the map, is $675,000.

Q. You mean as exclusive of that longitudinal section which is occupied by the tidal sluices, or do you mean if built across the river without tidal sluices? A. Without tidal sluices.

Q. That is, $675,000 would build, according to your best judgment, a complete dam across the river, and of the type you propose, but one not provided with these tidal sluices? A. Yes, sir. In the absence of tidal sluices it would be nearly a solid embankment.

Q. Except for the wasteway sluices, the locks and the

regulating ports? A. Yes. The tidal sluices will add $225,000 to the cost of the structure, making $900,000 as the estimated cost of this dam if equipped with all the features shown on the drawing, and if located at point *B*, or 650 feet above Craigie bridge.

Q. Then the extra cost of those tidal sluices is $225,000? A. That is the additional cost, as near as can be estimated.

Q. (by Mr. DUNBAR). How far is that above Craigie bridge? A. Six hundred and fifty feet.

Q. (by Mr. MATTHEWS). Did you give any figures of cost at the last hearing? A. I think not; no, sir.

Q. Now, then, so far as you have got, I understand you to say that a dam of the type you propose would cost, at point *B* on the map, at the bend in the river above Craigie bridge, $675,000; and if it were built with tidal sluices, according to the suggestions to which you have referred, it would cost $900,000. A. Yes, sir.

Q. Now, what would be the cost of such a structure placed immediately below West Boston bridge above Broad Canal, and reaching over to Charlesbank, at a point some distance below West Boston bridge, at point *A*, as shown on your map? A. The location on which an estimate in that vicinity was made was a line drawn from the north side of the west end of the West Boston bridge on a rather flat diagonal across the stream, striking the Back Bay side at a point about 200 feet north of the West Boston bridge; such location would avoid cutting off the mouth of the canal on the Cambridge side.

Q. Before you go on to that, let me ask you what was the object of having the Boston end of the dam strike the shore at a point so far removed from the West Boston bridge as 200 feet? A. It occurred to me in laying out the line that it would be convenient, after passing the lock, to have a little space between the inner end of the lock and the openings of West Boston bridge. A structure at that point on almost any line would probably tend to destroy the artistic effect of the structure now being erected. Although the dam, as shown by the profile in the middle of the blue print, would be a comparatively low structure, its architectural lines would jangle somewhat with the elevation of the new bridge. The main purpose in swinging the line of location was to give a little room between the lock and the piers of the bridge.

Q. Whether or not you had in mind the desirability of connecting the Charlesbank with the basin above the dam? A. Yes; that would follow in either case.

Q. That is, a dam could be located practically at West Boston bridge, so as to avoid Broad Canal on the one side and on the Boston side to give connection between Charlesbank and the basin? A. Yes, sir; that was the idea.

Q. What do you say about the estimated cost of a structure in that place? A. There would be so little difference that I should assume that this estimate of $900,000 would be nearly sufficient in that case.

Q. Excuse me, Mr. Blake, — you mean your estimate is $675,000 without the tidal sluices, and then $900,000 with them? A. Yes, sir. While the line at West Boston bridge is much longer, the amount of embankment required is but very little more, and the material of the embankment is the cheapest part of the whole structure.

Q. Then do I understand that you do not care to change your estimate made for site B? A. I should not change it. I would simply add this opinion, that there might be a variation of $25,000 or $30,000, due to some special work which it might be necessary to provide near the entrance of the canal, but it would be a detail for which we have insufficient information to estimate; the difference would be very small, if any, between the two sites.

Q. Now, have you made an estimate of the cost of such a structure as you propose at Craigie bridge in substitution for that bridge? A. If this type of dam, with its details adapted to the location, is made to serve the purpose of a bridge at the location of the present Craigie bridge, the cost will vary very little from $1,300,000.

Q. (by Commissioner DANA). That would be 120 feet broad on top? A. Yes, sir.

Q. (by Mr. MATTHEWS). Is that with or without tidal sluices? A. That is equipped completely as shown on the drawings.

Q. What would be the cost if you left the tidal sluices out? A. The addition of the tidal sluices at the Craigie bridge location would not entail much more expense than if located at West Boston bridge, or the location first named. The only excess in cost over the $225,000 I named, if any, would be due to peculiar conditions of the bottom; but I am inclined to think that the present pile structure of Craigie bridge would be worth something in constructing this dam, and would probably be worth enough to offset any difference in the cost of the tidal sluices, and perhaps offset a little of the cost of a portion of the embankment.

Q. Then, if I understand you right, the cost of such a dam as you propose at Craigie bridge, 120 feet wide, would cost, without tidal sluices, $1,075,000? A. Yes.

Q. And with the tidal sluices it would cost $1,300,000? A. Yes, sir.

Q. I notice on the elevations, Mr. Blake, a road running through the tidal sluices, or what appears to be a road, at least a line or continuation of what is called a roadway elsewhere, running apparently through the tidal sluice arches, or possibly behind them. Will you explain what is the meaning of that part of the diagram? A. That is a projection showing the continuation of the roadway behind the sluices. This blue-print shows an elevation from the basin side, looking down stream toward Craigie bridge, and that line is simply an addition to the plan to show the level on which the road is carried through. You understand that on a drawing of this size, drawn on a scale of this kind we can't show many of the details.

Q. Let me ask you this: these five arches and two towers which compose the structure of the tidal sluices are entirely in the upper part of the dam, are they not? A. Yes, sir; the plan above shows that.

Q. Consequently, the roadway is continuous from the Boston side over to the drawbridge? A. Yes, sir.

Testimony of William Jackson.

Q. (by Mr. Dana). What was the cost of Charlestown bridge? A. It cost about $1,500,000.

Q. What is the cost of the present new West Boston bridge? A. Two million five hundred thousand dollars.

Q. Has any estimate been made of the cost of a new bridge at Craigie bridge? A. No, no estimate has been made.

Q. Could you estimate what the cost would be? A. I should say about $1,250,000, — $1,000,000 to $1,250,000, including approaches.

Q. Would that be an ornamental bridge? A. A bridge like the Charlestown bridge.

Q. If it was made as ornamental as the West Boston bridge, how much would probably have to be added to that estimate? A. Five hundred thousand dollars, at least.

Q. What did the Charles River bridge actually cost? A. The actual cost, land damages and all, about $1,500,000; that includes the approaches.

Q. (by Mr. Dunbar). Do you mean the Harvard bridge? A. No, the lower bridge, the Charlestown bridge.

Q. (by Mr. Pillsbury). Does that include, or is it exclusive of, what the Boston Elevated Railway Company paid? A. That does not include what they paid.

Q. Do you remember the amount they paid? A. They only paid the cost of their structure itself; they did not pay anything towards the bridge. The law required the bridge to be built to carry their structure.

Testimony of Percy M. Blake — *resumed.*

Q. (by Mr. Matthews). Now, Mr. Blake, I am going to ask you to explain to the committee, in greater elucidation than you have, the mode of operation of this dam in its several parts. Take up the lock first. What do you care to say about the operation of the lock in particular? A. There is nothing very novel about the lock. It will operate under rather favorable conditions. The rolling gates controlling this lock are to be carried to a height sufficient to exclude the high water on the harbor side, and the method of emptying and filling the lock I think is clearly shown on the drawings. The time of passage through this lock ought not to exceed twelve or fifteen minutes, in no case over twenty minutes. It is practicable to put accelerating appliances on the side of the lock to pull a vessel through, so that it will be possible to pass a vessel from the harbor through this lock into the basin without the use of a tow boat. The accelerating device would be of the windlass type, operated by an electric motor. The basin gate being opened, the ship could be pulled through into the basin. There being no occasion for haste after passing through the lock, such as there would be in passing through the series of drawbridges below, the vessel could be warped, with the aid of dolphins driven into the basin, to the entrance of the canal.

Q. On what do you base your opinion that it would not take a vessel over twenty minutes, at the outside, to pass through the lock? A. General experience in canals, and also the inquiries which I have made. I have the official reports of the operation of locks on the Erie Canal at Lockport and Cohoes. The time stated in each case is less than that which I have indicated for this very simple lock. The time required to empty or fill this lock will be less than seven minutes under the average head which would prevail between the two water levels. The actual time of opening the gate would be less than ninety seconds, and the time of actual passage into the lock ought not to be over four or five minutes.

Q. You have correspondence in respect to these canals at the locks which you have mentioned? A. Yes, in form of

replies to letters of inquiry which I wrote. The correspondence relating to the Erie Canal is as follows: —

ALBANY, Jan. 30, 1902.

Mr. PERCY M. BLAKE, *Newtonville, Mass.*

DEAR SIR: — In answer to your favor of January 29, I give the following data regarding the time of locking boats on the Erie Canal: —

In the report of the State engineer for year 1891, page 447, it was stated that the steamer "James M. Morse" and one consort consumed an average of fifteen minutes and five seconds in passing through the 16 locks at Cohoes and the short levels between them. A boat drawn by horses with one consort averaged sixteen minutes and forty-nine seconds per lock. Fifteen lockages of boats drawing 6 feet averaged seventeen minutes and thirty-five seconds. Long locks which take two boats fastened together consume twenty-two minutes for each lock for a fleet of four boats. At the single tiers of five locks at Lockport 80 boats can be locked through in twenty-four hours.

Regarding the lockages in the improved locks proposed for the barge canal, I would refer you to the barge canal report of the State Engineer for the year 1901, page 610.

A copy of the report of the State Engineer for 1891, and a copy of the barge canal report, are sent you by express to-day.

Very truly yours, EDWARD A. BOND,
State Engineer and Surveyor.

Q. As I understand it, Mr. Blake, the figure twenty minutes which you have assigned as the outside limit of duration of operating this lock is your idea of the extreme figure, — conservative estimate? A. Yes, sir; and allowing for some clumsiness in management. It ought to be done in twelve to fifteen minutes.

Q. Your opinion is that with proper management the lock should be operated in from ten to twenty minutes? A. The time of passage should not exceed twelve or fifteen minutes.

Q. That is, from the stand-point of the vessel? A. Yes, sir.

Q. Would that speed of operation be obtained in any of those three sites at which this dam is proposed to be located? A. That would pertain to any of them except the Craigie bridge location, where the vessel might be subjected to a little delay in handling, in entering and emerging from the basin through the lock, for lack of space, perhaps.

Q. Lack of space on the lower side? A. On the lower side of the proposed dam. There is less space there than for the other two locations.

Q. Now will you take up the question of operating the regulating ports, Mr. Blake. I would like to have you go into that matter with considerable detail, and explain to the committee exactly how these ports would be operated, from every stand-point. A. For the regulating ports the type

of gate would be the positive, balanced pattern, revolving on a vertical axis. The gate, when closed, would fill a port 7 feet wide, the dimension shown on the drawing. The thickness of the gate in the middle will be 12 inches. When it is open, and the horizontal axis of the gate parallel with the axis of the port, there would be a thickness of 12 inches taken out of the width of the port, making an effective width of 6 feet. While the gate would never be perfectly tight, the leakage would be insignificant. Those regulating ports could be opened singly or conjointly. They would be operated by a line of shafting passing at right angles across the sluiceways, and would be geared into this shafting at the top, so that any one of them could be thrown out of gear or all operated at once. They could be operated singly or together. The mechanism would be very simple, strong and inexpensive. The tidal sluice gates and the sluice gates for the wasteway would be of the vertical balanced type, the height of the gate in each case being sufficient to allow the bottom to rest on the sill, and the top to be at elevation 14. They would be operated by a winding-up device with gearing requiring but very little power to operate it.

Q. (by Commissioner Dana). How would it operate when there was ice in the river? A. These sluice gates are to be located on the basin side, directly below the path of the inspector. The tide water would have access to the harbor side of the sluices, and there would be little or no difficulty there from ice. The type of sliding gate is such that, unless the ice blocks it at the top, there is no difficulty whatever in raising it. As soon as it is raised there would be no difficulty whatever. In intensely cold weather all of these gates on the basin side holding back the fresh water would require close attention, and there might be a few weeks in the year when it would be necessary to cut away the accumulation of ice. In my opinion, there would be no difficulty whatever by taking the precaution to cut away the ice in extreme weather.

Q. That would be one advantage of sluiceways? A. That was one of my objects in suggesting them.

Q. (by Mr. Matthews). One of the objects of the wasteways would be the handling of the ice? A. That would be one object, and another would be that the wind in summer, in warm weather, would drive the drifting material that might collect along the Boston side of the basin towards and through the wasteway.

Q. Is there anything further that occurs to you having regard to the mechanical operation of the ports? A. No,

sir; there is nothing. I think the simplicity of the port will speak for itself. There is nothing novel in the proposition. Sluices of this type are in use in England, and I think that anything successfully used in England can be improved upon here, perhaps.

Q. Now I will ask you to repeat what you said a little while ago. These regulating ports are larger by about 30 per cent. in the aggregate than those designed by the State Board of Health? A. In their effective discharging capacity they are.

Q. And they go down deeper? A. They go down deeper.

Q. Now, will you explain to the committee the occasions upon which and the purposes for which these ports would be used? A. The regulating ports would be the only outlets which it would be necessary to use — except in case of extreme fresh-water land floods — to keep the water in this basin clean and in proper condition. The next thing to be used would be the wasteway sluices, and they would be opened for the purpose of floating ice away, and possibly a little débris which might tend to collect on the Boston side. That would be drained or skimmed off the surface, rather than through the ports. For the regulating ports it would not always be necessary to operate the sluice gates wide open, or all of them at once. The surface flow had better be taken care of, when it became necessary to do so, on the Boston side; that is, the skimming of the top water on the Boston side where the débris might collect, if anything of that kind should be found in the basin.

Q. You say that in the main and except in times of freshet or for the purpose of skimming the débris off the river, off the Boston corner of the basin, these regulating ports would be the only openings necessary for the satisfactory operation of the dam? A. Yes, sir; and the operation of them would produce all of the results which are shown in diagram B.

Q. How near the harbor line on the Cambridge side would the lock be if the dam were built exactly as shown in this blue-print of yours? Is the harbor line shown on that? A. It would be about 115 feet as shown thereon.

Q. (by Mr. Pillsbury). Outside of the harbor line? A. Outside the harbor line; yes, sir. Of course the distance can be made anything that is desirable.

Q. (by Mr. Matthews). That is what I wanted to get at; whether or not, in your opinion, if that dam were built at site *B* on the side of the river above Craigie bridge,

it would be necessary to have the lock located exactly where it is as shown on this blue-print, or whether it would be necessary to have the tidal sluices or regulating ports or wasteways in exactly the same place? A. No, sir; not necessarily. This is not a hard-and-fast plan. The details would be regulated by future careful study, — a more detailed study than I have had an opportunity to make.

Q. Possibly you had some reason for putting the lock on the Cambridge side rather than on the Boston side. A. Yes; the reason which suggested itself to me was that the upper canal on the Cambridge side would be better reached. Another reason is, that the construction of this lock out in deep water will add quite materially to its cost. The lock as shown in the drawing is located at a point where it is believed a good foundation may be had at reasonable expense. If this lock were to be constructed farther out in the middle of the stream, where the water was 10 or 15 feet deeper, the work required to support the lock structure would be much more expensive.

Q. That would apply if it were built at site *B*? A. Yes. There is another reason, and that is, if there were a great deal of important navigation between the upper canal on the Cambridge side and the harbor, and it became necessary in extremely cold weather to keep a clear path through the ice, it would be much easier to do that on the leeward and warmer side of the basin.

Q. Speaking of the item of cost, you say, as I understand you, it would cost more to put the lock in the middle of the dam, if built at point *B;* but if the dam were built just below the West Boston bridge at point *A*, there wouldn't be that difference in cost, would there? A. No, because the channel below West Boston bridge is very different both in its dimensions and location. The profile of the river at that point is such that the location could be carried out near the high span in the West Boston bridge, and still not reach a very much greater depth of water, — certainly not so great a depth as you would reach if you were to put the lock in the middle of the dam, if located 650 feet above Craigie bridge, or at point *B*.

Q. Have you got the profiles of the river at different points? A. Yes, sir; four or five different points. They are not finished up in presentable form. I have cross-sections and profiles.

Q. Have you got those with you? A. No, sir; I have not.

Q. Can you have those prepared? A. Yes, in any form you wish.

Q. I should like to have you submit profiles of the river, particularly at those three points, — Craigie bridge, the point just above Craigie bridge and at West Boston bridge, — that is, along the three several locations you suggest. While I am on this question of profile showing the bottom of the river, I would like to ask you what you mean by the statement in your report, where you state you estimate your quantities by going down to 4 feet below the bottom of the river only. A. The proposed dam is to be an earthen embankment, with side slopes of 2 on 1 as near as they may be built in that class of work. It is shown on the cross-section just above the lower drawing. As this material is deposited on the bottom and accumulates weight, which it will do quite rapidly, it will tend to settle, and will compress any soft material below it perhaps one-half, possibly not so much. But I have assumed that there may be mud or compressible material averaging over the area perhaps 8 feet, and when the embankment is constructed that material may be compressed into one-half its bulk, — which is an entirely safe assumption and warranted by experience. Consequently, in figuring the total quantities of material I have assumed that the bottom of the material forming the embankment will find its bed 4 feet below the top of the present profile. Of course nothing but a very careful survey by soundings or borings will determine accurately where it would go, but in my opinion that allowance is more than safe in this case.

Q. Speaking of borings, you have accurate borings of the site proposed at West Boston bridge, have you not? A. I have hardly enough to warrant any closer statement than that.

Q. Didn't the bridge commission take borings along there? A. Yes. There was nothing in them to show that that statement is not liberal. I made an examination of them, but they were not complete enough to cover all the territory which this line swinging away from the bridge would occupy.

Q. What would be the width of this earthen dam at this point at the basis of it, at the bottom of the river? A. That would depend on the depth of the water.

Q. At any one site you have selected. A. In a depth of 30 feet the extreme width from toe to toe of the embankment would be about 200 feet. It would be a little less than that if mathematical lines were made. It would vary somewhat according to the depth of the water. It would be four times the depth of the water plus the top width. It can be easily ascertained; possibly the toe line would crush out a little.

Q. Now, the quantities which you have arrived at in figuring out the cost of the dam at the three several sites are all predicated on the same assumptions as to the depth and final resting place of the dam? A. Yes, sir.

Q. And differ only because of the indications in those cross-sections of the river, profile of the river bottom, and so forth? A. Yes, sir; and the depth of the water.

Q. Now, have you said everything that occurs to you of the use to be made of these regulating ports? If so, we might pass on to the wasteway sluices. A. I have, except this, possibly, which was suggested by an inquiry by Colonel Mansfield on Friday as to the effective velocity of the water through these ports. To determine the discharge through all of those ports under the fluctuating conditions which might prevail owing to the tidal action on the other side, would involve a complicated calculation and the determining of a point where the two slopes meet. The slope of the water going out of the port at low tide might be represented by that [indicating], and the slope of the tide coming in represented by that [indicating]. When these two slopes become the same plane no water will flow out. That is, the superior head is lessened as the tide rises. Now, to determine precisely the point which I assume Colonel Mansfield had in mind would involve quite a complicated calculation; but I have taken, as sufficient for the purpose, an average velocity due to a difference of head of 2 feet. I assume the velocity of water flowing from the basin subsides as the water falls; which would be true, but not precisely the case here, because the element of inflowing land water complicates the problem. I can give you the velocity in feet per second with a head of 2 feet in the case of each port and in the case of each sluice; and if you desire, I will put those in now.

Q. Yes, sir. A. For the regulating ports, beginning with the basin full in the first place, and ending with the basin containing but 2 feet of water, the mean velocity, assuming the tide to recede at a uniform rate, would vary from 7.82 to 7.41 feet; in the tidal sluices from 8½ to 8 feet; in the wasteway sluices it would be about 7¼ feet.

Q. (by Commissioner Dana). You mean feet per second? A. Feet per second.

Q. Of velocity? A. That is velocity of movement. That is to be multiplied by the cross-section of the opening in each case as the water recedes.

Q. (by The Chairman). The largest velocity was 5.7 feet per second, wasn't it? A. That was presented in the

table simply as a basis for a convenient unit. I will prepare a study and present it in the form of a diagram, if the commission desires to have it, showing the effective discharge of water on the fall of the tide and on the rise of the tide until the equilibrium is established by the harbor water reaching the level of the water in the basin.

Q. (by Mr. MATTHEWS). With different kinds of openings you get a different velocity for each kind of opening, don't you? A. Yes, there would be a velocity due to the head.

Q. I understood you to state there was a difference between the velocity of the water flowing through the regulating ports and the velocity flowing through the tidal sluices. A. There is.

Q. Now, the figures which you used in your preliminary report of last Friday were simply assumptions? I think you took 2 feet per second, and 3 feet per second, and 5 feet per second, did you not? A. I did not assume. They were not assumptions exactly. I did not assume those were velocities that would prevail in practice, but they were data put in that I thought the committee might find useful in application.

The CHAIRMAN. We understood it perfectly.

Q. Now you say, in your opinion, founded upon this calculation, in actual practice the velocity would be what you stated to-day? A. Under the conditions I have stated to-day.

Q. (by Commissioner DANA). I would like to ask whether, without the tidal sluices and with only the regulating ports and wasteway sluices, it would be possible to empty the basin at one tide? A. No, sir.

Q. (by Mr. MATTHEWS). Now, will you state anything that occurs to you regarding the operation of the wasteway sluices that you have not already given? A. Well, I have already described how they were to be operated. As to the effect of operating them, that is rather a complex proposition. As to what you might accomplish by operating those sluices, that is rather a simple proposition. Of course it is evident that, with all these water ways in use, you cannot restore the tidal action below the dam in the same form in which it now exists, because the outflow of the tidal prism as it now passes any of the cross-sections where the dam may be constructed is like the forward march of the front rank of a large army. But with these openings in the dam in use, to get the same body of soldiers through they will have to scramble pretty fast in comparison with

the solid front movement. Consequently the effect of letting the water out through these openings on the ebb tide will be that the tidal action will not be immediately restored. It will be possible to empty this basin through the sluices in about the same time that is now required in the lowering of the water to the point which would be reached in such emptying; but the immediate local effect below the dam will be that the stream will not become regulated as to its flow until it gets down to a point nearly opposite the Navy Yard.

Q. Are you talking about the tidal sluices now? A. Yes, sir.

Q. What you have just been saying relates to the tidal sluices? A. Yes, sir, specifically; and generally to all the openings.

Q. (by Colonel MANSFIELD). You mean with everything open? A. Yes, sir; you can't empty the basin in the same way in which it is now emptied, but I think through these openings you can empty it down to a point 2 feet above low tide.

Q. Would you have to open everything to do that? A. To do that you would have to open everything very nearly wide. I hardly think the lock would require its full water way to do that.

Q. (by Mr. MATTHEWS). Have you anything to say in regard to the operation of the wasteway sluices, in addition to what you have said? A. No, sir. They would be effective for lowering only down to a level perhaps 2½ feet below elevation 8, although they would drain down to elevation 3; but the flow through them would lose its velocity so much that below that depth they would not be particularly effective.

Q. In regard to the possibility of emptying the basin in the time of a single tide, I understand you to say you can do it by means of sluices, tidal openings and other things down to grade 2, 2 feet above mean low water in a single tide? A. Yes, I think there is no doubt about that.

Q. How much lower could you go than grade 2? A. That would depend somewhat upon the amount of land water coming in, but on some spring tides I think it would be possible to lower it 1 foot below that grade.

Q. And am I correct in understanding you that, while the effect of the outflow of the tide through these openings immediately below the dam would not be the same as under the present conditions, the effect of the flow of the water will be about the same as in the present conditions after you

reached a point opposite the Navy Yard? A. I think so, substantially. I spoke first of the local difference in velocity on the cross-section at the point where it was proposed to construct the dam. Of course the effective water way of the sluices is a great deal less than the water way of the whole present cross-section, and must be made up in increased velocity, in order to get through the quantity of discharge which the full cross-section now allows of passing.

Q. You mean the velocity entering through the dam? A. Yes, through the openings in the dam.

Q. There wouldn't be any increase in velocity down near the Navy Yard, would there? A. I think there would be no difference noticeable after passing Charlestown bridge, or as soon as the stream expanded. The main difference would be measured between the dam and line 2 on the map.

Q. Now, Mr. Blake, assuming that it is desirable that this basin should be operated as a tidal reservoir in the future, what do you say as to the result or effect upon the lower channels of the harbor of cutting off the lower 2 feet of the tide, — that is, of emptying the basin at each tide down to grade 2 instead of down to grade 0, as now? A. It is my opinion that the last run of the tide is injurious rather than advantageous. I think that is the position taken by all the authorities who have intelligently and thoroughly studied the subject. The commissions which have reported upon Boston harbor have laid great stress on the value of the fourth and fifth hour of the ebb tide discharge, and have criticised, as at least non-useful if not injurious, the last hour of the ebb tide. The first set of the ebb tide is very moderate.

Q. Then, in your opinion, even if it becomes desirable, in the opinion of the United States government, to continue the operation of the Charles River as a tidal reservoir, you can get fully as much result on each ebb tide with a dam constructed as you have designed it, as you have got to-day, having reference to the condition of the lower channel? A. Yes, sir; with the exception of the loss of the upper 2 feet. This basin will cause a loss of perhaps 2 feet of tidal prism, which there will be no way of making up, but the operation of the tidal sluices may produce as much good effect almost on the latter part of the ebb tide (if there is any good effect) as you now find.

Q. (by Mr. PILLSBURY). That is only by opening the ports and sluices at ebb tide? A. Yes, sir.

Q. (by Mr. MATTHEWS). What do you say as to the comparative value to the lower channels of the upper 2 feet

of the tide and the last 2 feet? To what extent, if any, in your opinion, will the cutting off of the upper 2 feet of the tide be offset by the cutting off of the last 2 feet? A. Well, if the conclusions as to the causes of the slight deposits which have been noticeable in the harbor are correct, — that the lower part of the ebb current or lower part of the ebb tide has done this damage, — there is a gain in efficiency by closing off that part of the flow. I find no evidence of any measurable improvement or advantage arising from the use of the upper 2 feet; and I fully agree with the commission of 1860, when it says in its report that they have, after their long and laborious study of ten years, discovered traces of causes rather than any effects.

Q. Mr. Blake, in your opinion, would the loss to the lower harbor of the upper 2 feet in the tidal reservoir be offset or made good by the gain to the lower harbor by withholding the last 2 feet of the tide, or would there still be a preponderance of loss? A. In regard to the lower harbor, my opinion is that neither the upper 2 feet nor the lower 2 feet have any value whatever in the lower harbor.

Q. I mean from the narrowest point between East Boston and Boston? A. My opinion is, that the exclusion of the tidal prism by the construction of this dam will have no effect whatever, one way or the other, on the harbor.

Q. You mean even if it is not operated as a tidal basin? A. Yes. But if experience should show that there were slight tendencies one way or the other, and that the provisions made in this dam could be used to advantage, the provisions would be there and they could be used; but in my opinion the exclusion of the tidal prism here would have little or no appreciable effect, but if it had any effect it would be just as likely, and rather more likely, to be beneficial than otherwise.

Q. I think you said this morning this idea of tidal sluiceways was not your idea at all. A. I did say so. I never have believed in providing them. I don't believe they are necessary. If they have any effectiveness, and are to be continually used to produce that effectiveness, the value and main object of the basin would be defeated.

Q. Having regard to the practicability of this basin and the effect of the dam upon the harbor channels below, I wish you would state to the committee in full your views, and the reasons why you conclude that it will not be necessary or desirable to operate the Charles River as a tidal reservoir. A. As to the effect upon the channels of the harbor, it is my opinion that no measurable harm can come

from the exclusion from the harbor of the tidal prism of the present basin. The actual value of the fresh water in the ebb flow is so small that it has no importance as a scouring force. The alternating flow of the quantity of water represented by the tidal prism gives no resultant of measurable advantage to the upper harbor. If the dam is constructed the upward flow of this quantity of water will cease, and hence the velocity of the flood current in the upper part of the harbor will be appreciably reduced. Alternating tidal currents have two functions, one being the erosion of the shoaler bottom and channels through which they flow, the other the transporting of the materials eroded and the sediment and débris collected from land sources. If there is no material eroded, there will be none to transport. If the flood current is lessened, there will evidently be less power to erode and less material to be transported into the upper harbor and the basins beyond by this current.

If the ebb current now transports material eroded from the river bed or the shores of the basin into the harbor, such material will be deposited in the basin formed by the dam and prevented from reaching the harbor channels.

It is my opinion that if all the tidal basins above the upper harbor were closed to tidal action, the flood currents in the upper harbor would be so reduced that they would be incapable in themselves of producing much change in any portion of the bottom of this harbor, and would become too feeble to transport what little they might erode.

It is my opinion that the construction and maintenance of the proposed basin will actually benefit the upper harbor by lessening the velocity of the flood tide and its power to transport material; and that thereafter the section of the river between the basin and Charlestown bridge may be reduced in width to such dimensions as may be sufficient only for the uninterrupted flow of fresh-water floods of the river, and for convenient approaches to the few wharf privileges lying on either side of the stream within this section. I am aware that is a radical position to take, but I am willing to take it and defend it.

Q. That statement which you have just made represents your final conclusions upon this particular point? A. Yes, sir.

Q. As I understand you, you simply incorporated in this design these tidal sluices at the request of counsel? A. I did, sir.

Q. As a means of still utilizing the basin as a tidal reservoir, in case the United States engineers thought it desirable to do so? A. Yes.

Q. Is that your idea? A. Yes, sir.

Q. Now you say that this basin with these tidal sluices can be emptied on a single ebb tide down to grade 2. That, I take it, is capable of mathematical demonstration, is it not? A. Entirely so.

Q. I wish you would prepare that diagram, showing that calculation in detail. Do you care to say anything about the methods of construction of the proposed dam? A. The cross-section on the blue-print contains a suggestion as to the way in which the main embankment may be constructed. The principal difficulty in this case is the making of an embankment with an alternating tidal flow taking place in the section in which it is located.

Q. Mr. Blake, suppose it should become desirable to empty this basin for purposes unconnected with the tidal scour, or from causes occurring in the basin itself, and suppose this dam were constructed without these tidal sluice gates, what time would it take to empty the basin down to grade 2 or grade 0? A. Without using the lock, in the drier months of the year, when probably the occasion would arise if at all, the water could be entirely renewed, or rather the basin could be entirely emptied in four or five days, without any doubt, taking advantage of the ebb tides, and the portion of the rising tides when the water would be low enough to allow emptying to go on.

Q. You mean grade 2, or grade 0? A. I don't think it would be emptied to grade 0 ordinarily, but to grade 2 or 1½.

Q. That is, by using the regulating ports and the wasteway? A. The wasteway sluices for the upper part of the water.

Q. Making no use of those tidal sluices? A. No, sir.

Q. Will you submit calculations on that point? A. Yes.

Q. What could be done, Mr. Blake, if it were desired to do it, to get rid of the last 2 feet, the lower 2 feet, of the water in this basin?

Mr. Pillsbury. You mean above mean low water?

Mr. Matthews. Yes.

The Witness. If you mean to draw off that particular layer 2 feet deep, it could be done by drawing the water from the lower level by means of the submerged ports.

Q. You have not said anything about these submerged ports this morning, and I wish you would explain their operation and the reason for suggesting them and the use which could be made of them. A. I think the function of those ports is clear enough. They simply serve as a suc-

tion pipe going down into the deep water. The power which will drive the water up and force it through those ports will be the superior head, due to the difference between the elevation of the water in the basin and the water outside. In that way the bottom water would be drawn out and the top water be replaced by new water coming in. That process would be much more marked in the admission of salt water, which would result in raising the water level in the basin. The difference in the specific gravity of the two waters would probably preserve the line of demarcation between them, except perhaps in the upper part of the basin, where there might be active currents.

Q. Those ports, then, could be used for the purpose of drawing off the water in the lower strata of the basin? A. Yes, sir.

Q. And you said also something just now about their being used for the purpose of introducing salt water? A. Yes, sir.

Q. I wish you would explain to the committee what the result would be on the water in the basin itself. A. Well, I can illustrate the value of that process by referring to diagram B. The drawing off of the water from the bottom would result in drawing some of the solution out from the bottom, and then by a reverse flow of salt water the level of the water in the basin could be restored and maintained at or near high-water mark. The value of the process would not be very great, and in my opinion it would not be necessary to use it.

Q. You say it would take four or five days to empty this basin in summer, if it were not furnished with these tidal sluices? A. I don't know as I have said in summer, but that would be probably the time you would want to empty it. In dry weather, with the ordinary flow of the stream running, it might take four or five days.

Q. Do you remember how long it was estimated to take to empty the basin under the scheme proposed by the joint commission of '94? A. I will not attempt to state, for I do not remember.

Q. It must have been a very much longer period, wasn't it? A. It must have been a longer period ; yes.

Q. I think you said on Friday that those ports could be used for the introduction of salt water into the basin? A. Yes.

Q. For the withdrawal of the lower strata of the basin and replacing that water with salt? A. Yes.

Q. And that salt water you said would lie at the bottom? A. Yes.

Q. If it were found desirable to do that at any time,

would the admixture of fresh and salt water in the basin have any injurious effect, in your opinion? A. Not to the extent of being noticeable, especially if it were introduced in the quantities proposed. A substitution of all of the water in the basin by salt water by means of those ports would hardly be practicable.

Q. What do you say, in a general way, about the effect of maintaining this basin on the health and sanitary conditions of the neighborhood? A. I will say generally it will improve all the sanitary conditions in the territory adjacent to and on either side of the basin.

Q. Referring to page 6 of your report submitted to the committee, and the figures of capacity given on that page, from what data were those figures computed? A. You refer to the filling of the land?

Q. I refer to the last sentence, beginning, "The total storage capacity of the present basin (within the harbor lines defining the proposed basin) below mean high-water level, between Craigie bridge and the first dam at Watertown, is, as near as can be estimated, 466,000,000 cubic feet, of which 84,000,000 cubic feet will lie in the upper stratum of 2 feet, leaving 382,000,000 cubic feet below elevation 8;" and to the continuation of that statement on page 7, where you say that "323,000,000 cubic feet are stored between mean high water and mean low water." I want you to state to the committee the facts and data on which those calculations are based. A. That is the total storage capacity of the basin between Craigie bridge and the first dam at Watertown, obtained by a great many cross-sections laid out upon the government and State maps containing soundings, the quantities being obtained by careful calculation by the usual method, using the prismoidal formula, and I believe them to be as close as it is possible to get them in such a case.

Q. Those calculations were done by yourself? A. In my office, by myself and my assistants.

Q. And founded on government surveys? A. Founded on government and State surveys. The statements on the top of the page are based upon the survey of 1853.

Q. You mean statements referring to the area of the proposed flats? A. Yes, sir.

Q. Mr. Blake, in the operation of this dam, how would you manage the freshet problem? If the upper basin should be filled by heavy rains at a time coincident with high tides and easterly storms, what would prevent the water behind the dam from rising to grade 14 or 15? A. Such conditions would have to be anticipated in order to be met, and to anticipate such conditions there must be a little

more intelligence in the management of the dam than we ordinarily find in a draw tender, for instance. An intelligent management would soon learn to anticipate a condition of this kind, and, anticipating it, would take pains to empty the basin before the maximum effect of the storm or the flood, or both combined, could reach the basin. That is one of the tenderest points in the management of the basin. But the provisions of those wasteways is so ample and the quantity of water which the basin will hold for each foot of increased depth on its area of 830 acres is so large as to make the problem an easy one to solve and control.

Q. Would it, in your opinion, be a relatively easy matter for an intelligent manager of this dam to foresee such a condition of affairs and to guard against it? A. Perfectly so, because we have that process going on constantly in the management of large water supply basins; for instance, in the Nashua River water supply, the Sudbury basins in the metropolitan district, and other large basins in different parts of the world. Of course in this case we have an element which is very seldom met with, that is, a tide rising twice a day, and sometimes rising to unusual heights. The moment the rising tide passes above elevation 8, it is as effective a cut-off as a tide gate. The time during which the wastage can take place is limited by the rise and fall of the tide. At such time all the discharging capacity of the basin will have to be brought into play, and with such a flood as we had in 1886, and perhaps as the one we have recently had, the wasteway ports, the regulating ports and the lock, would be ample to take out of that basin, in the six hours available, or in a shorter time, enough water to provide for the maximum flood quantity that would flow in during the high tide. That I can demonstrate graphically, if you wish it. Studies have been made, but not yet put in diagram form.

Q. What harm would it do, anyway, to have the water rise in this basin to grade 10, 12, 13 or 14, once in a while? A. Well, it would be an occurrence similar to that which now takes place. It would be undesirable to have a thing of that kind happen, because structures and improvements on the bank of this basin would be designed to meet and would be predicated on a fairly constant level of the basin water at elevation 8.

Q. But it would be no worse than what happens to-day under similar conditions? A. No.

Q. Only it would be less frequent? A. Yes.

Hearing adjourned to Wednesday, March 5, at 2 P.M.

NINTH HEARING.

ROOM 240, STATE HOUSE, MARCH 5, 1902.

TESTIMONY OF PERCY M. BLAKE — *resumed.*

The hearing was begun at 2.15 P.M., Chairman Pritchett and Commissioner Dana present.

Q. (by Mr. MATTHEWS). At the last hearing, Mr. Blake, you promised to prepare some calculations and present some maps. Will those diagrams suggest the manner of taking care of the maximum amount of water? A. Yes, the diagrams are intended to show every possible use to which the openings in the dam may be put under all varying conditions, including use during extreme freshets, or fresh water on the land side, and extreme high tides, and coincidence of the two.

Q. You say on page 11 of your preliminary report something about the rising tide returning in large part such impurities as flowed out on the preceding ebb tide. I wish you would state to the commission what, in your judgment, is the character of the tidal inflow to this tidal basin on the flood tide. A. The special commission, in describing the course of the ebb current, says that in the case of a particle of water starting in the Mystic River it will probably not reach the Navy Yard in one ebb tide; that a particle leaving the Navy Yard may not go half way to the mouth of the harbor in the whole ebb tide. As the basins drain and the water drops in the last stages of the drainage process due to the outward ebb flow, the dregs, if there are any, and the sediment from the guzzles in the banks and bottom will be washed into the stream. If we take a particle which leaves the basin mid-way in the period of the ebb flow, it will of course return to its original starting point in twice the time that it requires to reach its farthest point down the stream. In other words, the last hour of ebb flow will be the first to return. It is very much like drawing a train from the railroad station, — when you back up, the rear cars come in first. The rate of velocity of the tidal flow averages not exceeding 1 mile an hour, and the last half of the ebb flow is brought back by the flood and contains the larger part of the sediment which started down the stream, not only of the Charles basin but of all the

other basins which contribute to the ebb flow through the channel between Boston and East Boston.

Q. How does the back water coming in with these tides compare in purity with the sea water? A. I can't state that precisely, but it follows from the physical movements in the case that fresh sea water from the Atlantic Ocean never reaches the Charles River basin.

Q. What do you say about the effect of this dam upon the purity of the water impounded behind it? A. This dam by proper management will increase the purity of the water as compared with its purity under present conditions.

Q. Have you any fear of stagnant water in the popular and offensive meaning? A. No, sir; not if the basins are properly managed and the draughts of water made at the right time and at the right level.

Q. What would the average depth of this basin be? A. Ten feet over its whole area, as obtained by dividing the total contents of the basin by the surface area.

Q. What do you say about the possibilities of growths, and their effect upon the purity of the waters in the basin? A. Of course you refer to fresh-water growths after the basin is constructed?

Q. Yes, sir. A. In the first place, the present bottom of the proposed basin, as far up as the water is measurably salted, is now in a semi-sterilized condition. That bottom is not coated with a fertile, nitrogenous mud, such as we find in old ponds or in unclean areas flooded with fresh water by artificial dams. As the river water flows in, it will not bring much of that kind or quantity of sediment which, when deposited on the bottom of a reservoir, furnishes a nidus for rank vegetation. The growths largely offensive in fresh-water basins are those containing large quantities of nitrogen; that is, soft, succulent growths, which in their decay give up large quantities of ammoniacal products. In this basin, in the absence of what we may term fresh-water deposits and fresh-water mud, there will be very little encouragement for such growth. The water of the Charles River is remarkably free from sediment of that kind, but it is likely that in some years, and certain warm portions of some years, there may be seen on the edges of the shoaler portion of the basin some vegetable growths. But the opportunity to draw the basin down will make it feasible to sterilize the banks or to remove anything of that kind; and the amount of such growths I should expect would be so small as to affect in no way the quality of the water or the condition of the local atmosphere.

Q. You have something in your preliminary report on the subject of draining Stony Brook into the metropolitan high-level sewer. A. I have a diagram here showing that.

Q. Mr. Blake, will you also show, if it be a fact, how Stony Brook could be drained into the Boston system as well as the metropolitan? A. This blue-print, which is a blue print of the sewer department of the city of Boston shows all the details of the Stony Brook channel and the sewer passing under it. That is located at the corner of Parker Street and Huntington Avenue, at a point where the Stony Brook channel deflects and discharges into the Fens basin. I described this for the purpose of showing what may be done here. In the bottom of the Stony Brook channel— there are two channels marked "gutters," and being in the bottom and below the water line of the Stony Brook channel, it is possible to drop through those gutters and the provisions made for that purpose, the dry-weather flow, or a considerable portion of it which would naturally contain such sewage as would be flowing through the channel and at a time when it would be offensive, and pass it off into the main sewer of the city of Boston, which would conduct the flow of the sewage down to the pumping station. It is a valuable opportunity if used for the purpose of taking care of this portion of the dry-weather flow of the channel. This is a provision made by the city of Boston. I have no authority to say that it would be allowed to be used in that way, but there is no mechanical difficulty in using it for that purpose. It occurred to me it might be useful in connection with the opportunity to draw the basin down so that access may be had to this conduit by inspectors or workmen. By scraping, the bottom of the conduit could be cleaned out and the dregs delivered into the sewer and not washed through into the basin. There is no doubt of that being feasible.

Q. Have you anything on the subject of ground water, Mr. Blake? A. I have investigated the matter of ground water very carefully.

Q. And what do you say on the question of ground water in its application to this question? A. The ground water now stands throughout that territory at elevations varying from about 6 feet to nearly 9. The Metropolitan Sewerage Board made certain investigations by boring into the ground around the vicinity of the proposed high-level sewer pumping station. The data which they obtained, together with the data I found in the evidence previously given, and which I have found by consulting other plans, show the

ground water to stand at from about 6 to 9. In my opinion, the establishment and maintenance of a water level at elevation 8 in this basin will not materially change the level of the ground water. One reason for that opinion is this: The Back Bay area was originally enclosed by what observation showed to be a fairly tight embankment, known as the mill dam, now called Beacon Street. That dam was built for the purpose of controlling and using the tide water, and while I do not remember it, — it was much before my day, — I have taken pains to inquire as to the construction of the embankment and have been assured the embankment was a remarkably tight one. That is but a small detail in forming the opinion. In a level territory like this, the water in the ground, unless withdrawn through some artificial channel, such as a sewer or sub-drain under a sewer, is regulated by such areas of standing water as may exist in that territory. The elevation of the water in the Fens basin is maintained at elevation 8; the water in the upper portion of that parkway in the Brookline territory is held at elevation 11. The bottom of neither of those basins is water-tight. The water cannot sink materially below the level of the water maintained in those basins in the Back Bay territory, unless, as I say, it finds its way out through porous sub-channels. Again, the territory is very large in area, that is, the flat portion. It is not fed from surrounding water-sheds having steep banks, and the only rise and fall of water in that flat area is due to the rain falling on the surface. A large portion of the Back Bay territory was filled with gravel drawn from the town of Needham, the gravel banks just beyond Riverside on the Boston & Albany railroad, and that gravel has a porosity of from 30 to 35 per cent. That means that a gravel bed or an area filled up with gravel of that kind will, for each inch of rainfall, hold about three inches of water, which on that territory would raise the water level in the soil not over 3 or 3½ inches. It is my opinion that the only variation in the level of the ground water after the basin is built will be the same as it is to-day, or that due to the rain falling on the surface.

Q. Would there be any possibility of developing malarial conditions, in your opinion? A. I hardly dare to touch on malaria, although I have had samples of it in my family. I should prefer to leave that subject to the medical profession. I can say that on my construction work for the last twenty or twenty-five years I have noticed cases occasionally where fresh earth was turned up.

Q. What about the possibilities of solid deposits accumulating in this basin? A. Of solid deposits?

Q. Yes, solid deposits or deposits of any kind. A. The only sources from which such deposits might come would be the channels that bring in storm water on different sides of the basin, and the sloping banks or guzzles in the channels which lead into the basin. The stream itself will bring in no appreciable amount of sediment as it passes the Watertown dam. Unless the catch-basins which are located along the line of the drains discharging into the basin are neglected, there should be nothing more than a very small amount of sediment. If it accumulates at any one point it would probably have to be removed by dredging; but unless it occurred in very deep water or below low-water mark after the basin is constructed, it could be reached by staging and wheelbarrows, and taken out very easily and applied to some use or carted off, probably at less expense than if it were to be dredged.

Q. Have you considered in this preliminary report the opportunity to clean or flush the overflow sewers? A. The opportunity to adopt a very different method of flushing would be afforded by the construction of the basin, because the water in the basin could then be drawn down and held down at a very low level. This could be done by deliberate intention at the end of periods of good weather when anticipating a rainfall, so that when the scouring forces were in play they would be more effective in cleaning the sewers out than at present.

Q. Have you anything that you care to say as to the form of the present tide gates of the sewer outlets and as to the possibility of their improvement? A. Not specially. If it becomes necessary to provide access to tide gates on the ends of these outlets it can be done by some simple bulkhead construction, or if the present tide gates are of a design which sometimes give a little trouble a more modern type can be substituted, in which the tide gate and the frame are one and the same, and may be bodily raised and lowered.

Q. Turning to page 17 of your preliminary report, I wish you would state how you get the population of 12,000 persons, and just what that figure represents in your opinion. A. The intention of that calculation was to ascertain how large a population could be taken care of by the flow of water in the stream, aided by the facilities for storage. The 12,000 was obtained by trial. In making calculations of this kind we do not get results until we have performed the calculation. That, I think, will be understood by the com-

mission. In reaching this result of 12,000 persons I first assumed a population of 15,000 would be taken care of. The curve was then developed and plotted. It was found, at the end of the cycle, that the right condition was not reached, and a population of 10,000 was then tried. It was evident there was a greater margin in the opportunity than that, and 12,000 was then found to be the number which would prove by that method of demonstration.

Q. That is, 12,000 represents the population which the dam will take care of, on the basis of allowing 10 cubic feet per second per 1,000. A. Per 1,000 persons. The sewage might flow continuously every day in the year.

Q. I understand you to say that, while that is for the average year, you would get the same results for a dry year? A. I should say substantially the same results. In a year of minimum rainfall it is fair to assume the sewers would overflow less frequently.

Q. Do you know how that population of 12,000 corresponds with the actual number of people draining continually into the river? A. I do not know; but, as compared with the figures given in the report of the chief engineer of the State Board of Health, it is from four to six times as large.

Q. That is, 12,000 is four to six times as large as the actual population which Mr. Goodnough estimates would drain into the basin? A. Yes, sir.

Q. According to Mr. Goodnough? A. Understand me, in each case I mean a population discharging all the time.

Q. Yes. This calculation that the capacity of the river is equal to the continuous drainage of a population five or six times as large as the population which Mr. Goodnough estimates would drain into this basin, is predicated upon serving 10 cubic feet per second to each 1,000 persons? A. Yes, sir; all of those calculations are.

Q. I see you state it is considered by the best sanitary authorities that a flow of 10 cubic feet of water per second per 1,000 persons is sufficient. I would like to ask if that isn't a high figure. A. Yes. That statement is not quite as I should have made it. I should have said that that is outside of the most generous concession made by the authorities. The authorities vary, giving as the quantity anywhere from 3 to 7 or 7½ cubic feet per second per 1,000 persons.

Mr. Matthews. At this point I would like to inquire if the committee has taken cognizance of the report of Mr. Asa M. Mattice to the Cambridge Board of Park Commissioners in 1894?

The CHAIRMAN. Yes, we have that.

Mr. MATTHEWS. It contains some data on this very subject.

Q. Please state the manner in which you reached the storage capacity under different conditions and at different levels in this basin as given by you on pages 6 and 7. A. The figures for storage capacity were all based first upon the maps containing soundings of the whole area. The figures were prepared by dividing the basin into sections and using prismoidal formulæ.

Q. On page 24 you have given certain results, indicating a population far in excess of that existing in this drainage area, and I would like to ask whether those calculations are based upon these Cambridge records before they were corrected or interpreted by Mr. Goodnough, or after and subjected to his corrections? A. They were based upon the records as I found them. I made no corrections. I had no data which would enable me to make corrections, and while I had some data which suggested corrections, I did not use them. I took the figures as I found them.

Q. Now, Mr. Blake, would the conditions within this proposed basin be anything analogous to those now obtaining in the Back Bay Fens? A. No, sir; not in any way.

Q. I wish you would explain to the committee the difference. A. Well, the Fens basin is practically a stagnant basin, not only in a scientific sense, having very little or no motion to the water, but it is far from pure at times; and the present means of renewal are so inadequate, cumbersome and inefficient that the condition of the Fens basin is practically the same all the time. The only water used in flushing now comes at times when the tide is high and the water in the proposed basin is very dirty, and this method of renewal is far from active or efficient.

Q. Is there any difficulty, in your opinion, in the construction of marginal sewers to carry either the dry-weather flow or storm flow of Muddy River or Stony Brook, or both of them, to a point below the proposed dam? A. Not for quite a portion of them. There may be structural reasons why the Stony Brook Conduit may require reconstruction, and I judge there are; but it would be far better, in my opinion, to let the flow go into the basin where it could be absorbed and neutralized than to attempt to deliver it at any point below the basin where the outflow would be so large and concentration so great that a local nuisance might be created. There is no doubt about the ability of this basin to take care of the flow.

Q. Have you made any estimate of the cost of dredging this basin to a point below mean high water? A. No, sir; I will do that if you desire it. Mr. Chairman, here is a cut illustrating the type of propeller engine which I suggested for renewing the water in the Fens basin. I have here for the convenience of the committee a drawing showing a typical overflow regulator. It is a fair sample of the mechanism of the regulator which is used in these cases, and I will call attention to one thing. That is, that the float is actually dependent for its motion upon the back flow from the metropolitan sewer, and it is frequently the case in practice that this is not carried to its full height, so that the regulator records presented are not conclusive.

Q. (by Mr. DANA). On what basis do you base your proposal to make the lock 40 feet wide and 356 feet long? A. The width which I suggest is 40 feet, depth 12 feet below low water. By inquiry I learn that the widest vessel which now passes through the drawbridges is a little less than 40 feet. The length is merely a suggestion, as I have shown it on the blue-print. It may be 50 feet longer or shorter. I have estimated on the length of the longest barge and the longest tow boat going by the drawbridge before the opening of the upper gate.

Q. Both the tow boats and the boat together? A. Yes, in extenso.

Q. And about the depth of 12 feet at mean low water. That is as deep as any vessels that go up the Charles? A. No, sir; I am informed that vessels occasionally go through to the Cambridge part drawing very nearly 16 feet of water; at half tide the lock would have a depth of 17 feet. I wish to say that the blue-print contains only suggestions, and I do not consider the dimensions given of any great importance, as they are subject to change.

Q. To let vessels go in at all stages of the tide, we need a deeper lock? A. I should hardly think so.

Q. At low tide? A. I should hardly think so, from the information which I learned from parties interested in taking those vessels through. It is not often that a vessel goes through at the extreme low tide; but, at the same time, it would depend a little on where the dam was located as to whether a vessel would be obliged to go through this lock immediately after passing the upper drawbridge. That is a structural detail, and it will be a matter of perhaps $20,000 to carry it two or three feet deeper.

Q. There is no advantage now in going through in making it any deeper, because they could not get up to their

wharves; but if we had a constant depth, they might go through at any tide? A. Yes, I can conceive of that; but if there was a demand, it would cost a matter of $20,000, perhaps, to add 2 or 3 feet more depth. It is a matter of dollars and cents only.

Q. (by the CHAIRMAN). In your computations did you include in your embankment anything about the ice thrust or any component due to ice, or did you consider the dimensions you gave it sufficient to take care of that in the whole structure? A. The ice thrust would be away inside the strength limit of the proposed dam. The width of the embankment is amply sufficient and the dimensions are more than ample.

Q. The factor of safety is sufficient to take care of it? A. The factor of safety is from three to five at least in all these cases.

Q. (by Mr. HAMLIN). Do I understand that there are any vessels that now can go up the river that would be excluded from going up by means of this proposed lock and dam? A. I should think that, with a depth of 12 feet, some of the vessels which now go up the river could not proceed at low water.

Q. But part of the time, now, vessels of any larger size could not go up? A. Yes, more than half of the time. With the proposed lock any vessel which now goes up could go up with increased facility.

Q. You were aware of the fact that the Legislature had authorized a drawless bridge. I wonder if you took into account the fact that that bridge was closed which now is open? A. No.

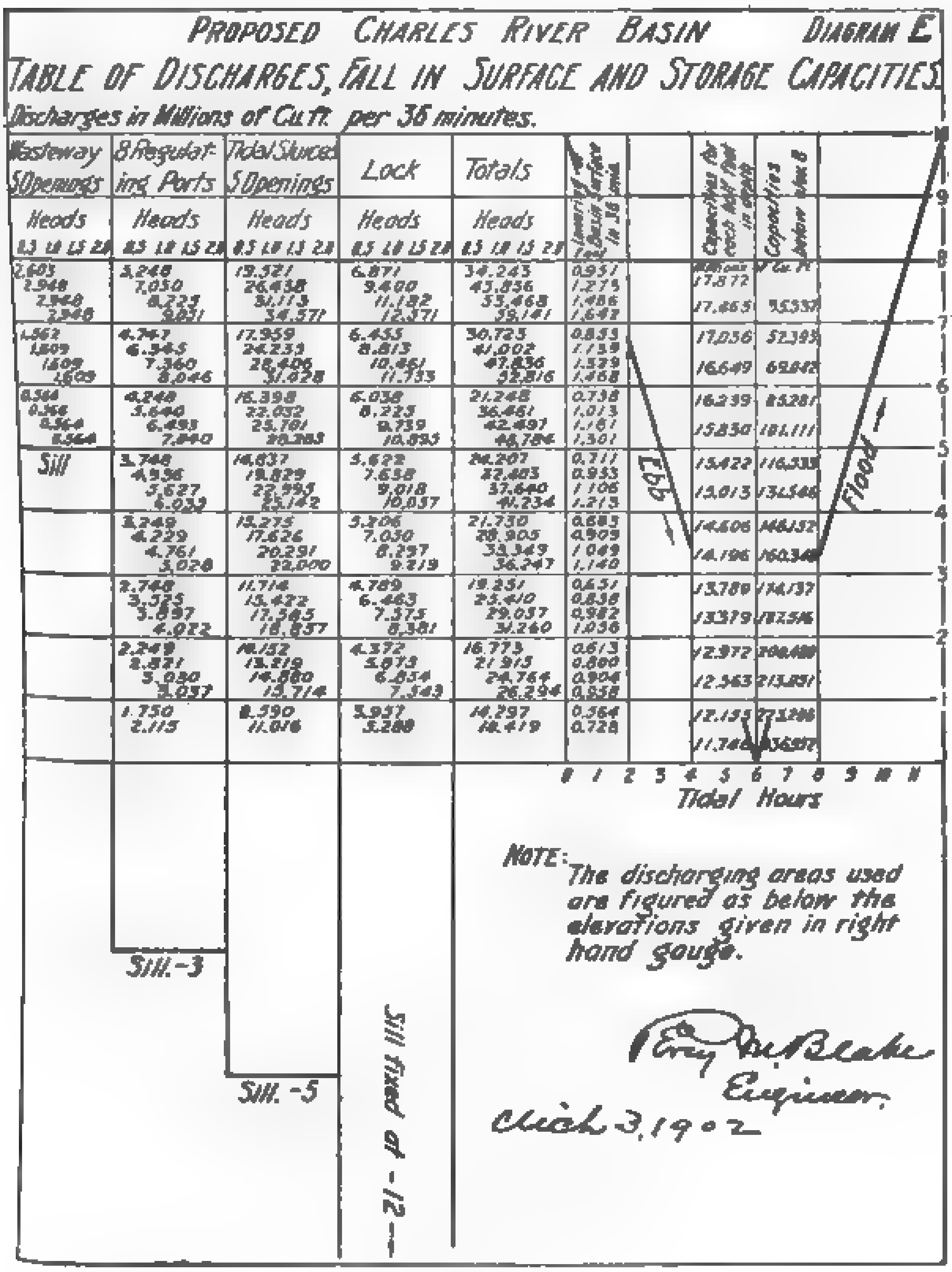
Q. You assume that there is a draw there substantially as to-day in all the bridges? A. Yes, sir.

Q. I would like to ask if there ever would be, in your opinion, any odor in this basin because of the storm overflow from sewers? A. No, I should say not, and not in any event any odor comparable with what we now get there. It is possible — I wish to be entirely frank in my opinion about these matters, for they are very important — that a very sudden rush of water through the Stony Brook conduit when that conduit was in a very neglected condition, in which it ought not to be, might temporarily cause a very little odor as the first rush of water came out. It would be a matter of a very few seconds' duration, and would soon be lost in the circulation which would be caused by the rush of the water. That would be purely local.

Q. And that would be caused by negligence, you say?

A. Well, yes; a great deal of the difficulty in the Back Bay Fens has been caused — I do not care to say by negligence, but by methods which might have been avoided.

Q. What would you say as to the purity of the water in



PROPOSED CHARLES RIVER BASIN DIAGRAM E

TABLE OF DISCHARGES, FALL IN SURFACE AND STORAGE CAPACITIES

Discharges in Millions of Cu. Ft. per 36 minutes.

Wasteway 5 Openings	8 Regulating Ports	Tidal Sluices 5 Openings	Lock	Totals	Fall of Basin Surface in 36 min. Feet	Capacities for each half foot in depth	Capacities below elev. 8
Heads 0.5 1.0 1.5 2.0	Heads 0.5 1.0 1.5 2.0	Heads 0.5 1.0 1.5 2.0	Heads 0.5 1.0 1.5 2.0	Heads 0.5 1.0 1.5 2.0		Millions	of Cu. Ft.
2.603	3.248	19.521	6.871	34.243	0.951	17.872	
2.948	7.050	26.438	9.400	45.836	1.275		
2.948	8.225	31.113	11.182	53.468	1.486	17.465	35.337
2.948	9.051	34.571	12.571	59.141	1.647		
1.562	4.747	17.959	6.455	30.725	0.853	17.056	52.393
1.609	6.345	24.233	8.815	41.002	1.159		
1.609	7.360	28.406	10.461	47.836	1.379	16.649	69.042
1.609	8.046	31.428	11.733	52.816	1.468		
0.564	4.248	15.398	6.038	21.248	0.738	16.239	85.281
0.564	5.640	22.032	8.225	36.461	1.013		
0.564	6.493	25.701	9.739	42.497	1.161	15.830	101.111
0.564	7.040	28.283	10.895	46.784	1.301		
Sill	3.748	14.837	5.622	24.207	0.711	15.422	116.533
	4.536	19.829	7.638	32.003	0.953		
	5.627	22.995	9.018	37.640	1.106	15.013	131.546
	6.035	25.142	10.057	41.234	1.213		
	3.249	13.275	5.206	21.730	0.683	14.606	146.152
	4.229	17.626	7.050	28.905	0.909		
	4.761	20.291	8.297	33.349	1.049	14.196	160.348
	5.028	22.000	9.219	36.247	1.140		
	2.748	11.714	4.789	19.251	0.631	13.789	174.137
	3.475	15.472	6.463	25.410	0.838		
	3.897	17.585	7.575	29.057	0.982	13.379	187.516
	4.022	18.857	8.381	31.260	1.036		
	2.249	10.152	4.372	16.773	0.613	12.972	200.488
	2.821	13.219	5.873	21.913	0.800		
	3.080	14.880	6.804	24.764	0.904	12.563	213.051
	3.037	15.714	7.543	26.294	0.958		
	1.750	8.590	3.957	14.297	0.564	12.155	225.206
	2.115	11.016	5.288	18.419	0.728	11.746	236.952

NOTE: The discharging areas used are figured as below the elevations given in right hand gauge.

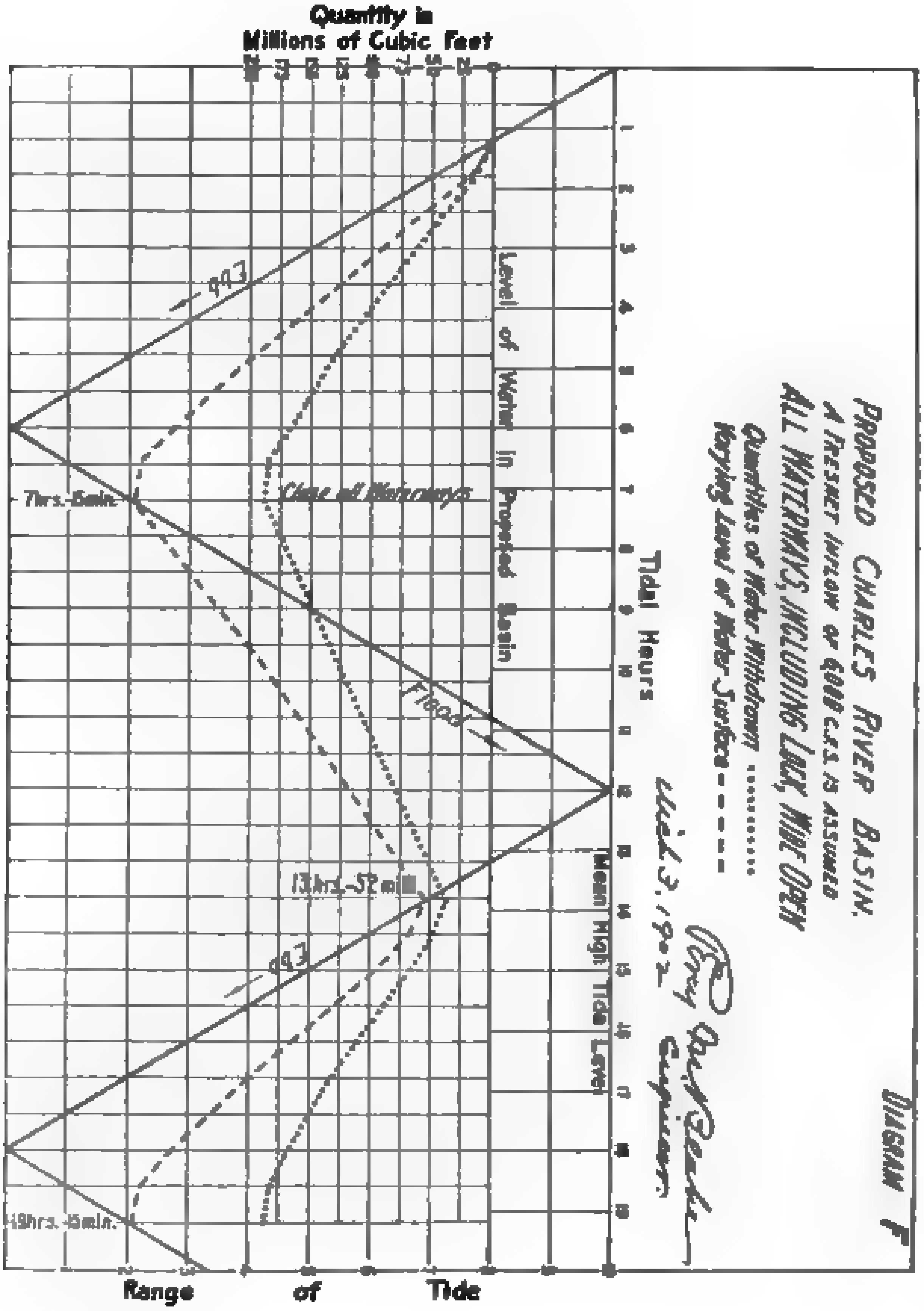
Percy M. Blake, Engineer.

March 3, 1902

the basin under those proposed conditions? A. I do not know exactly what you mean by purity. Purity is a relative term; if purity for the purposes of this basin I should say it would be practically pure.

Q. Would it be drinking water, for instance? A. Our

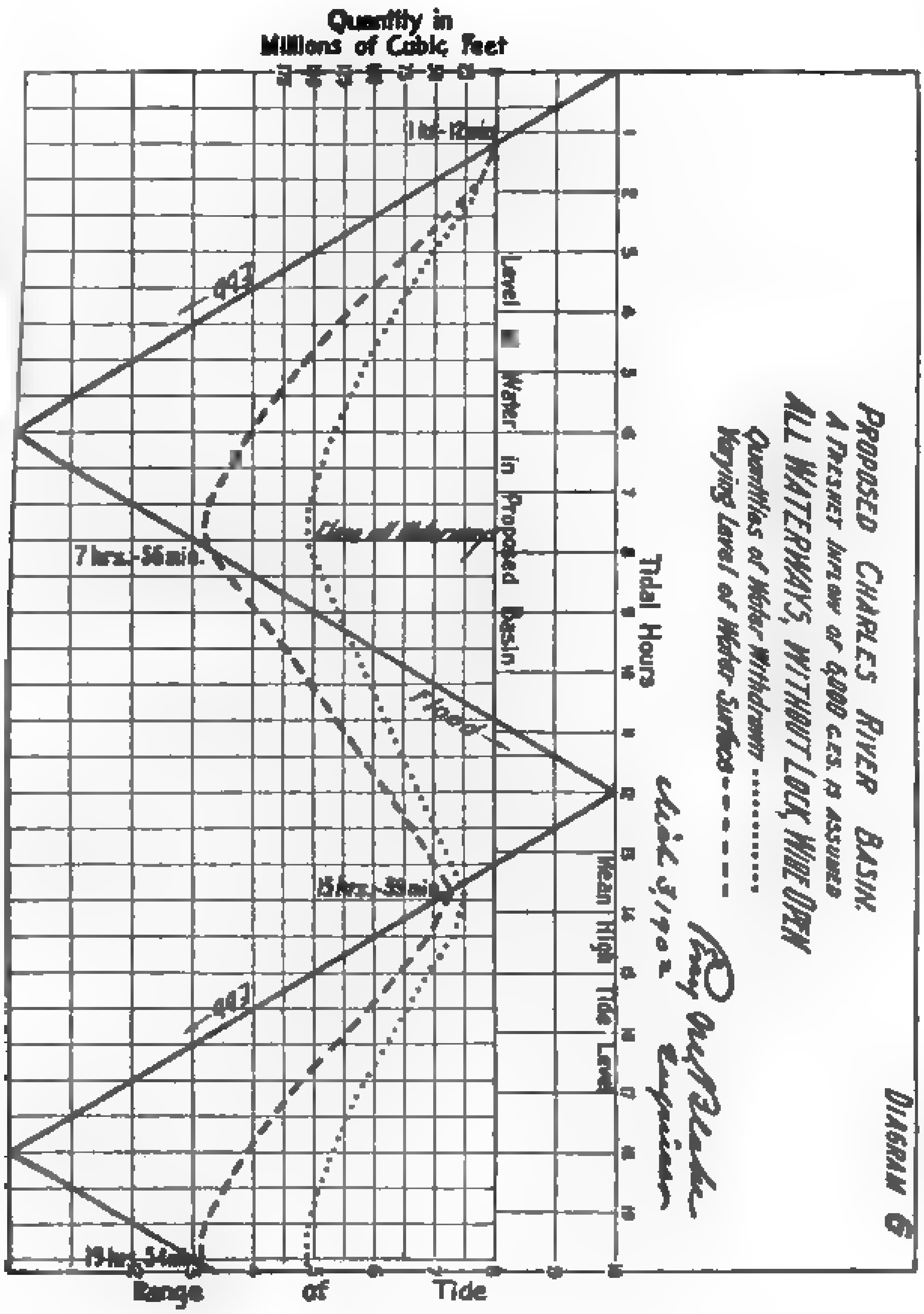
standards for drinking water are so high that I should not say it would be pure for drinking water; but I should not hesitate to drink it, say, out in the middle of the stream, if



I were sure that between there and Newton Upper Falls there were no typhoid fever cases.

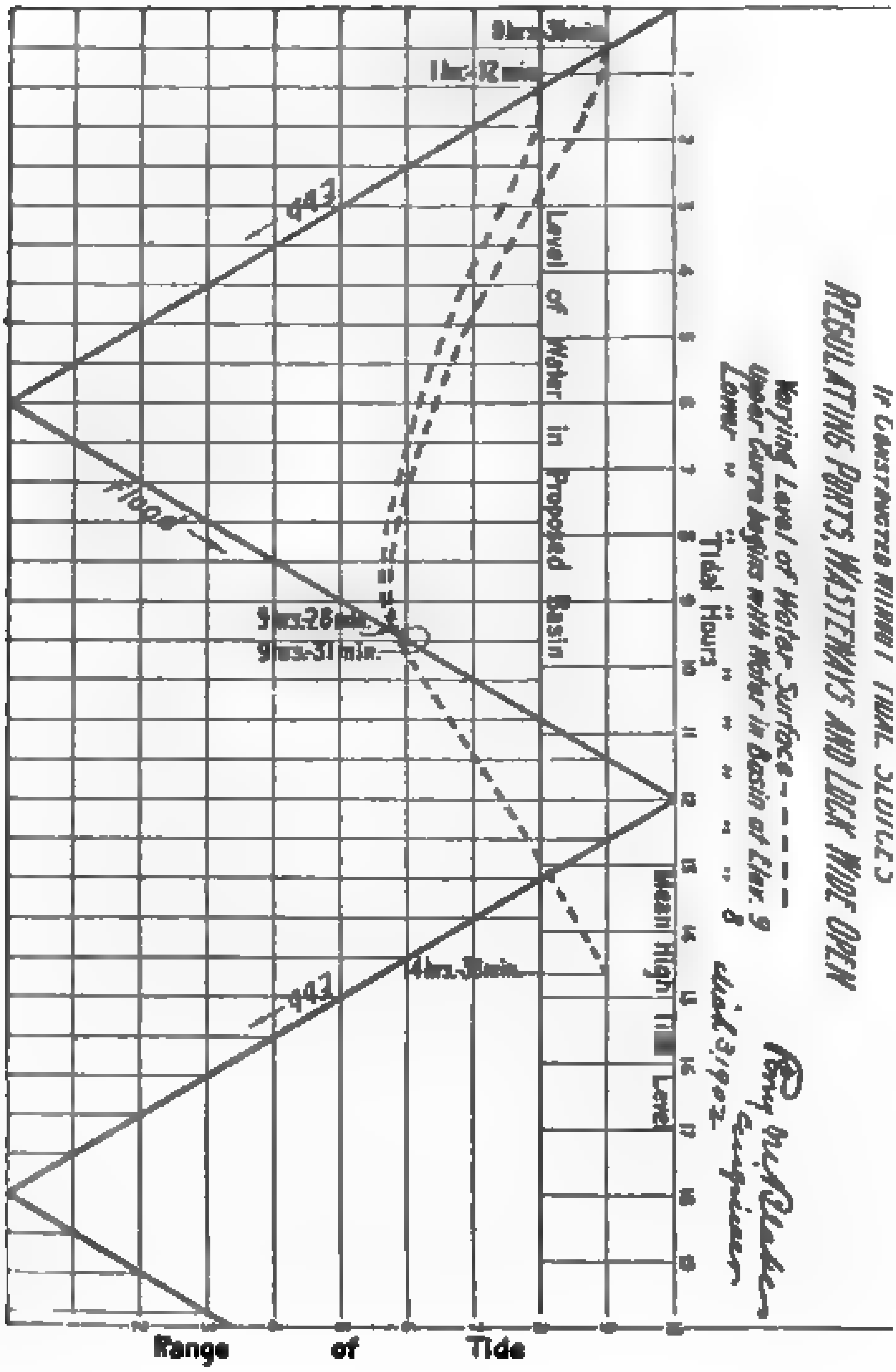
Q. Would you say it was pure from the manufacturing point of view? A. It would be excellent, except for the

purposes of white paper making; and no river water is quite pure for that purpose. For every purpose excepting those requiring an absolutely colorless water it would be pure



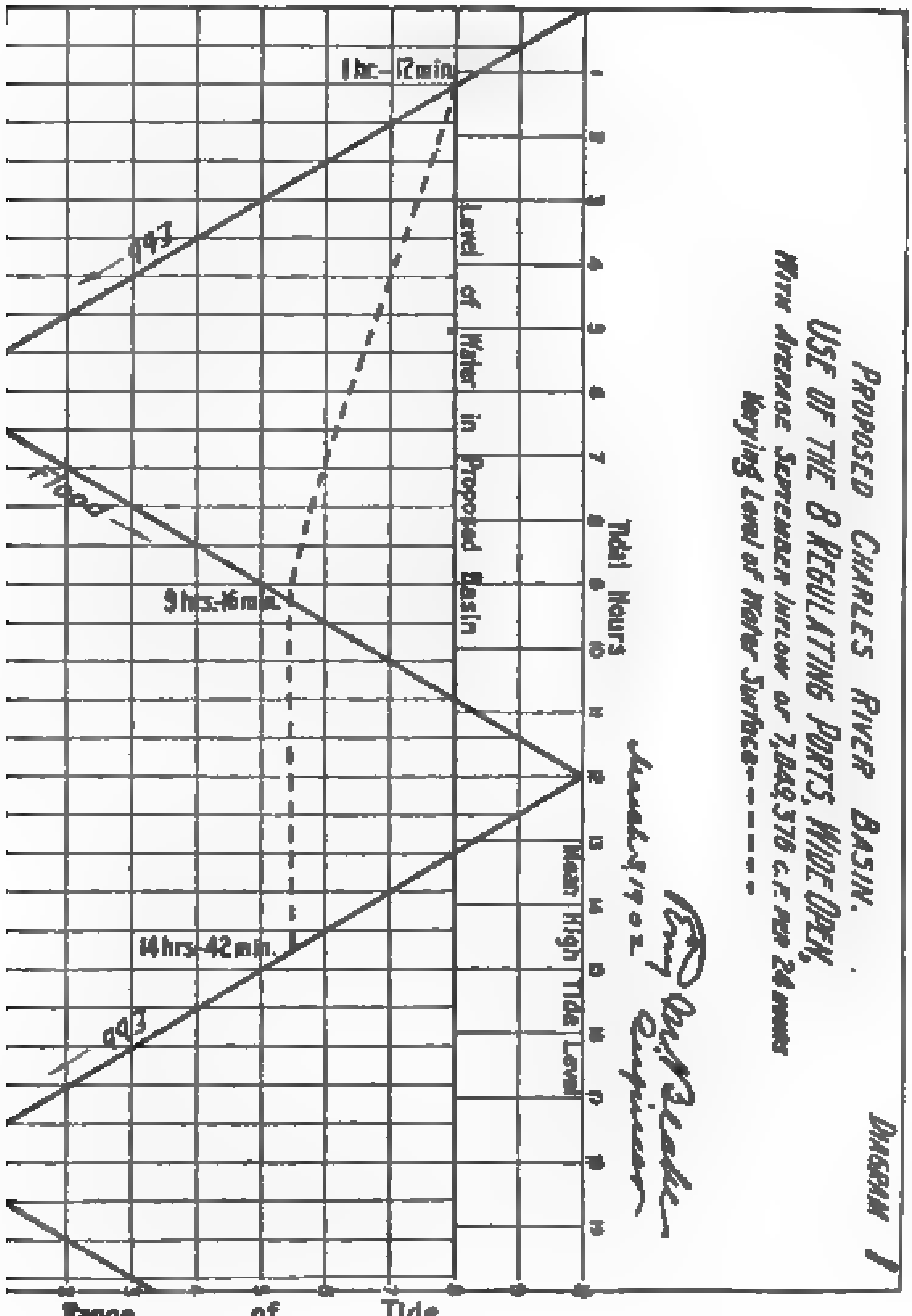
water; that is, it would be pure for ordinary purposes, for the generation of steam and everything excepting the manufacture of white paper.

Q. Supposing there were some negligence such a have spoken of, what would then be the difference purity of the water in the stream? A. Negligence



come from allowing long-continued accumulations channels, particularly in the upper or midway chann those conduits; but I do not wish to be understood a ing that any measure of importance, because there wo

long-continued pollution or contamination of the at-
sphere or anything of the kind. The condition of the
er as regards its dissolved oxygen is an extremely



portant factor. Fresh water is a great destroyer of im-
ities so long as it contains a slight excess of oxygen;
this water would come into the basin over the lower
tertown dam saturated with dissolved oxygen, and the

basin, having no background of hills or forests or high buildings, would be open to the action of the slightest breezes, and that is a factor which turns over and reoxidizes the water. It would be a remarkably fine basin in that respect for securing or maintaining a high degree of purity.

Q. Have you testified as to the current through the sluices? A. As to their effectiveness?

Q. No; as to the actual speed or actual current. A. I have not. I stated before you came to-day that I had some curves in process of completion that will explain everything you want to know.

Q. (by Commissioner DANA). Mr. Blake, I notice that you put the sluice gates at the opposite end of the dam from the lock. I was wondering whether it was for the purpose of taking care of the ice. Would it not be better to have those sluice gates near the lock? A. There might be a little advantage in that, but I thought of a disadvantage, and that in case of a strong surface flow out through these raceways it might interfere with the possible use of the lock. Another reason for placing them on the Boston side was that they would then be at the corner, where floating débris would collect.

TESTIMONY OF J. HERBERT SHEDD.

Q. (by Mr. MATTHEWS). Will you state to the committee your experience as a hydraulic and sanitary engineer? A. Hydraulic engineering has been my specialty in engineering for about forty-five years, and during that time I have had very much to do with the flow of rivers and the utilization of river water power; also considerable experience in establishing sewerage systems and in water supply. I have had special reason to study the matter of underground flow of water and the effect of currents in streams and harbors. I have been chairman of the State Board of Harbor Commissioners of the State of Rhode Island since the establishment of that Board twenty-six years ago, and therefore had reason from that fact to make a study of matters affecting the deposit in harbors and currents of water.

Q. What experience have you had in sanitation? A. I have established, or had to do with the designing or construction of some twenty-five systems of water supply, which of course involves the quality of water and the question of where it may be obtained and what tends to pollute it. I have also had charge of a large number of sewerage

systems, running from 1860 to the present time,—some quite large systems. The system of Providence is one that has involved the expenditure of something like five or six million dollars, which has been designed by me and constructed very largely under my personal direction. I designed sewerage systems for a large number of towns and cities.

Q. Have you done any work in that direction for Boston or in this vicinity? A. Not for the city of Boston in design. I have been consulted by Boston in several cases involving the use of water and value of water. I made a design for the city of Lynn, the sewerage system, and executed part of the work. I designed the sewerage system for Taunton, and executed a portion of it.

Q. Did you have anything to do with the Stony Brook or Muddy River? A. I designed the system for the town of Brookline, in which we dealt with the Muddy River and established the main lines there which are now in operation discharging through St. Mary's Street. There we had to deal with Muddy River. I made a study of Stony Brook for a good many years, especially with reference to its influence in Jamaica Plain and in that neighborhood, and also recently in regard to the question of injury to the Boston Belting Company's works.

Q. What work have you done in connection with this matter of the proposed dam and basin? A. I have spent considerable time for two months or more upon investigation of what is involved by the proposed damming of Charles River, and have devoted attention in that mainly to the effect which might come upon the harbor, and also upon the sanitary questions involved by the proposed establishment of a reservoir there.

Q. Have you drawn any diagrams or designs for the use of the committee in this case? A. With reference to the dam, I have, at the request of counsel. I have prepared plans for the use of sluice gates for the purpose of using a reservoir which might be established there in the method which is used abroad quite extensively in sluicing, and I did draw out those designs with reference to the gates with some detail. The general sketches which I made for the location of those sluice gates were only general, and I did make a sketch plan for the establishment of a dam and bridge on the site of the Craigie bridge, both in plan and in elevation. Those were sketches rather than plans which might be used for construction.

Q. I understand the special topic that you devoted your-

self to by way of designing was tidal sluice gates. A. Tidal sluice gates to be applied in a dam such as might be designed for the purpose generally. Of course I did consider the matter of gates for the discharge of ice and for the regulation of the basin under ordinary conditions of the flow of the river, in freshets and the ordinary dry weather flow. I also made a sketch for a lock.

Q. What have you there? A. I have here a suggestion which would be applicable to the dam if it were erected at the site suggested by the Joint Board, — flood gates and sluice gates.

Q. You have also suggestions for a dam at Craigie bridge, I believe? A. Yes, I made such sketches.

Q. Then perhaps you will explain, Mr. Shedd, what you have with you now? A. These are not much more than sketches, but they illustrate the possible application of sluice gates to a dam at the site proposed by the Joint Board, but at a low elevation of surface, at elevation 17; and at such low elevation of surface to insert tidal sluice gates it would be necessary to operate them in the plan which I have designed, to have more head room than we should have between the top of the gate and elevation 17, which would be used for the roadway. For that reason I had suggested an opening through the middle of the roadway, open to the top, so that a space 10 feet wide by 178 feet long in the clear could be used for access to gates.

Q. (by the CHAIRMAN). Is that the section of the top? A. That is the section of the top and that in clear and widened.

Q. (by Mr. DUNBAR). Ten by 178? A. For clear opening through the surface roadway. It was proposed to put into this dam five sluice gates, 22 feet wide and 24 feet high in the middle, to turn like an ordinary lock gate for locks in canals. The bottom of that gate would be at elevation 10 feet below mean low water. The top would be at elevation 14, making the gates, therefore, 24 feet high and to be 22 feet wide. That represents the abutments and piers, making a sketch for the location of five of those gates, one in each of the spaces between the piers. Those piers would be 12 feet thick in the middle portion of the pier, 6 feet thick at the end, so that the current of water approaching the gate would be decreased in cross-section in running from still water and a gradual increase in the velocity which would be developed where the water goes through the gateway. The bottom was also intended to be dropped at the outer limit of the piers, the outer limit of the dam, so that the bottom would rise in run-

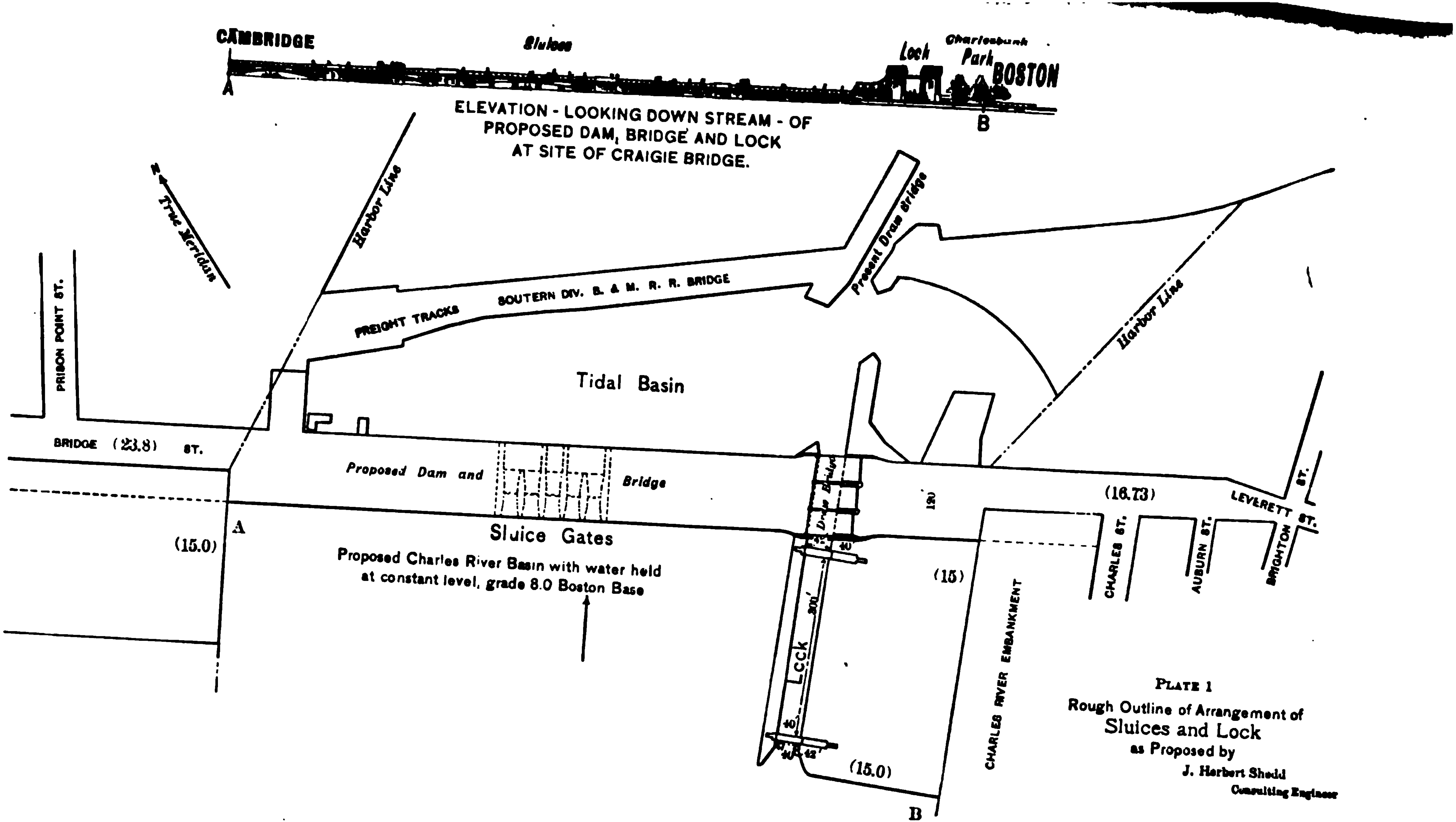


Plate 1

Rough Outline of Arrangement of
Sluices and Lock
as Proposed by
J. Herbert Shedd
Consulting Engineer

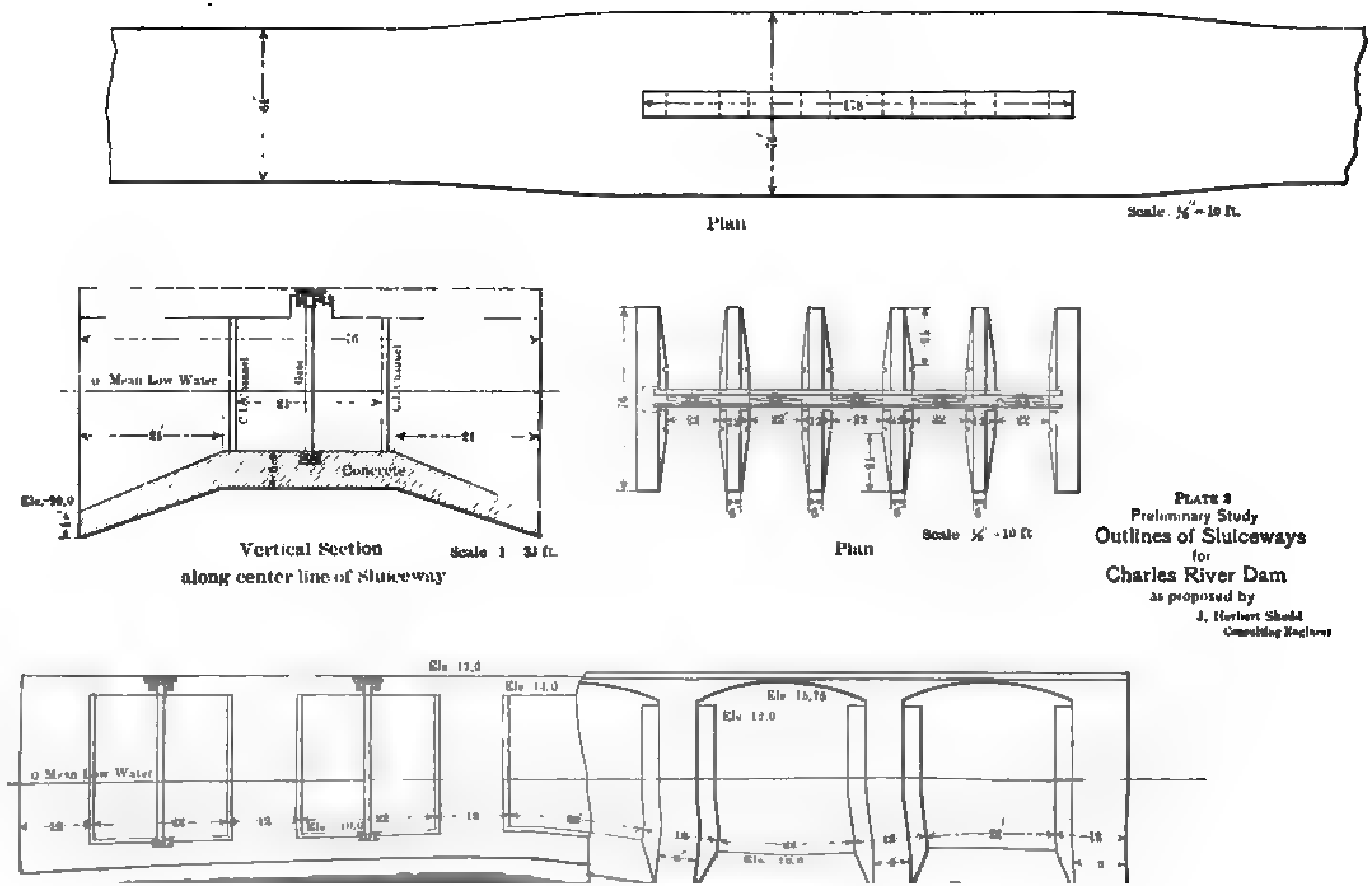


PLATE 3
Preliminary Study
Outlines of Sluiceways
for
Charles River Dam
as proposed by
J. Herbert Shedd
Consulting Engineer

ning from the outside portion of the dam to a level in which the gate would be operated, rising from 20 feet below tide to 10 feet below it, so that there would be a converging section of water allowing the velocity through the gate to increase to a maximum with as little loss as might be necessary,—that representing the longitudinal cross-section through the gate, this representing the plan through the gateway, that representing a section midway across the gate, and this illustrating an enlarged portion of the aperture in which the gate is placed. The gate, you understand, is hung in the middle on a shaft, and in opening swung so as to take this position [indicating].

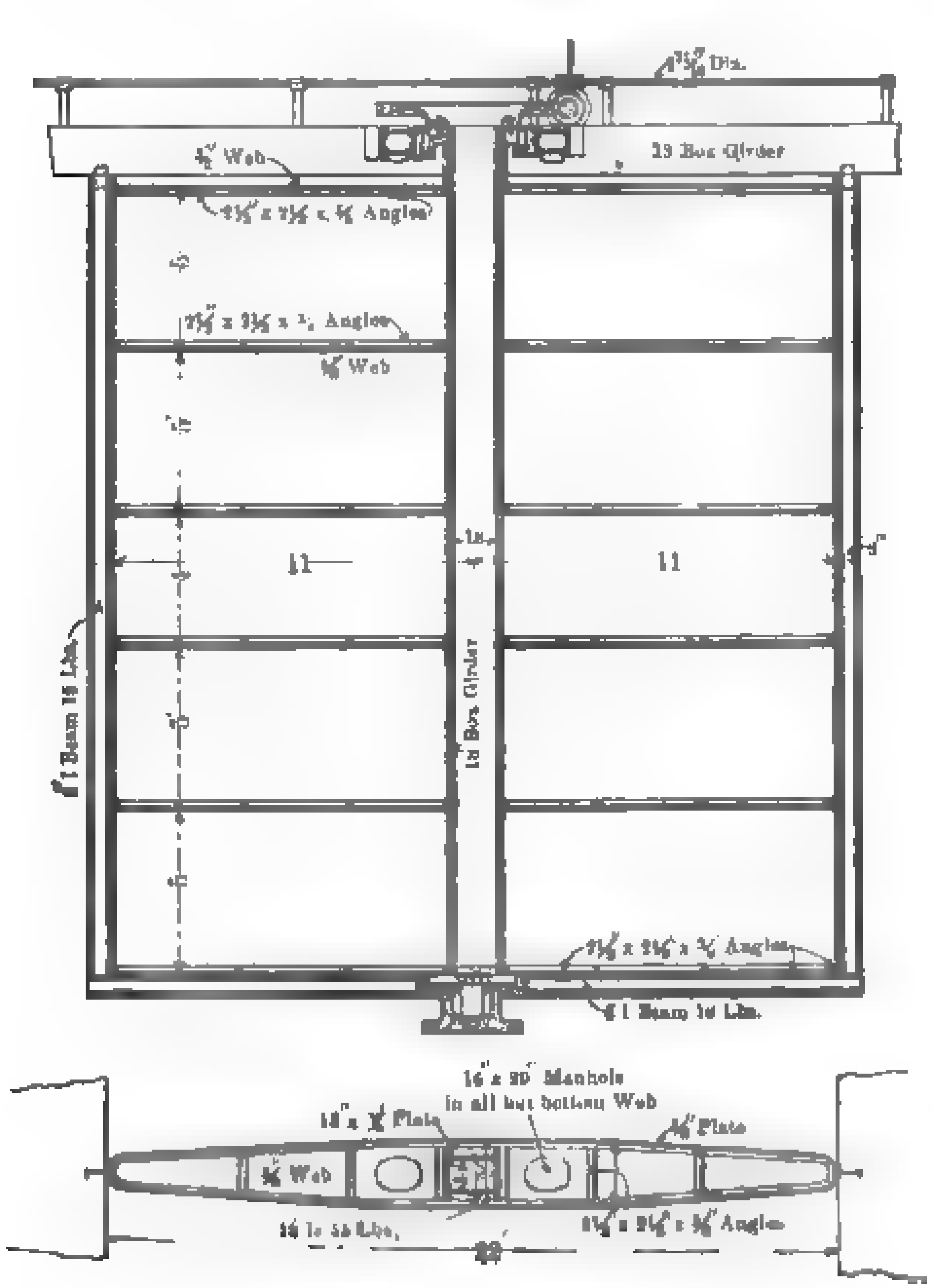
Q. What is this slope? A. That is the bottom and that is mean low water, and this is the bottom of the channel in which the gate is to be placed; and then there are to be channels on each side for putting in stop-planks, so that a pocket might be made there and that space pumped out, if there should be any reason to get access to the gate or take it out. It furnishes opportunity to cut off that gate for purposes of removal or for examination. That is the first sketch. Then that blue-print represents on a little larger scale the section of the pier and the openings as they would appear to a party on the outside viewing the structure, that being the mean low-water line,—what would be seen easily, and is what is above that line. This is a section representing the arch that would cover the space 22 feet wide in which the gate is placed, carrying the surface of the roadway, making the arch so as to support the roadway over the channel for the gate. That would represent the position of the gate and there the position of the stop-planks, and that is a ledge on which the arch would rest, and here is a cross-section the other way of the roadway longitudinally through the gate opening. That is, the surface of those lines represent I-beams strung across side to side near the arch. This is a section the other way through the arch. And what I have represented there is 12 feet for sidewalk, and roadway 18 feet; then the opening for access to the machinery of the gates and 18 feet roadway on the other side and 12 feet sidewalk all the way across, making 60 feet available all the way for the passage of whatever sort of traffic is allowed to go over that sort of structure, making the whole width of the structure 76 feet, 60 feet available for roadway. There will be 10 feet clear opening, and an opportunity for 2 feet of wall around the opening for ornamental purposes, or a stone wall, if it were necessary,—that would be thickness enough for it. And then the surface outside for the fence

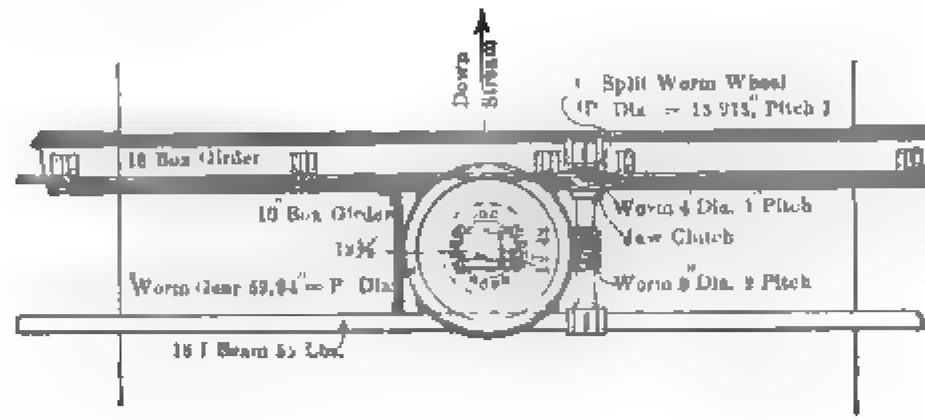
beyond the sidewalk and a little ledge outside of the fence makes 76 feet in all. That on a larger scale is the design for the gate and steel structure properly braced and divided by diaphragms through the plan very much like a lock gate or a large gate for a canal, — for the lateral movable gate, not the rolling gate. It would open on its axis, presenting the edge to the flow of the water. In the bottom there the step would be, like the ordinary step of a gate, or it might have friction rollers or ball bearings, — roller bearings I think would be desirable, but not necessary. Now, the method suggested for moving that gate is represented by the three drawings. Perhaps that one would be the first. Around the central shaft, which is a shaft about 18 inches square, there would be attached to the top of it a worm gear about five feet in diameter. That worm gear would be attached to the central shaft, and in the plan this represents the circumference of the worm gear, and there a shaft across held upon the steel frame, and that would enclose the upper portion of the structure; and upon that shaft a worm which plays in the worm gear, which is about five feet in diameter. On the end of that shaft would be another worm gear, and playing into that gear would be a worm and longitudinal shaft running past the five gates; and clutches would be on the worm shaft, on the main worm shaft, and would be adapted so that one or all of those gates could be turned at the same time, and that shaft would be run by electric motor, or whatever motor was desired. The plans represented there show that section one way in that drawing and the other way in the drawing which is part of the gate itself. That structure would be held in position by a box girder on one side and an I-beam girder on the other, supporting the boxes for the shaft, and resisting the pressure of the water under the most severe trial that could be brought upon it with low water on one side and 14 feet head or depth on the other.

Q. (by the CHAIRMAN). What arrangement have you got here for getting at it, for access? A. If it is necessary to take this out, these stop-planks could be put in and it could be pumped out. The whole is shown on a little larger scale here.

Q. (by Commissioner DANA). That is where they would come out? A. Yes, sir.

Q. Taken seriatum, one at a time? A. Yes, one at a time, and taken out. Of course I have studied the effect of the current in approaching these gates and in leaving them, and enlarging as it leaves them, and the protection of the bottom, like crib work.





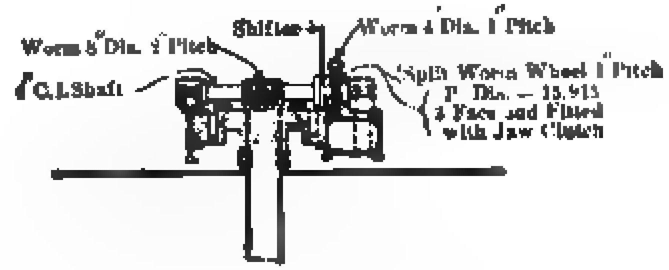
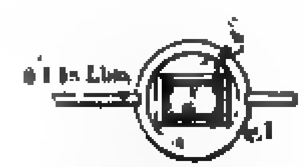


PLATE 3
Preliminary Study for
Details of Sluice Gates
for
Charles River Dam
by
J. Herbert Shedd



Q. (by the CHAIRMAN). Would there be danger of jamming these by ice? A. They are very strong indeed,— as strong as the Canadian large ship canals have used.

Q. Do you know of such a case in practice where such gates as those have to struggle with ice? A. No more than those of Canada on the Welland Canal. Of course they do not have those open all through the winter. This is a suggestion of a device which I should suppose would be very rarely used.

Q. (by the CHAIRMAN). Yes, I should suppose so. Probably never when the ice was in the river. A. Probably not; but if it were necessary to do it, the cutting of the ice for that short distance would be sufficient to take care of it. The sketch which I had made when the question was first asked me was of a dam and bridge at the present site of the Craigie bridge, with a side elevation.

Q. (by Mr. MATTHEWS). Have you stated to the committee the area of the cross-section of the opening for the discharge? A. That gateway is 22 feet wide and 24 feet high, and there are five in number.

Mr. MATTHEWS. I want to get a figure comparable to the figure Mr. Blake gave for his sluice gates, to see if those provide larger or smaller aggregate openings.

Q. (by the CHAIRMAN). There would be about a thousand square feet, up to 1,100. A. There would be a vertical height from grade 8, to the bottom of gate, of 18 feet. From grade 8 down to the bottom of the gate, or minus 10. The aggregate width of all the five gates is 100 feet. The thickness of the gate is 2 feet, the space 22 feet. The space would be still occupied when it is turned on edge to the water, still leaving 10 feet each side. The area then would be 1,800 square feet below grade 8 for the discharge of water.

Q. (by Mr. MATTHEWS). Do you happen to remember how that compares with the discharging area of Mr. Blake's sluice gates? A. No, I do not remember. These would discharge the entire volume of the basin from 8 to 2 in about four hours if the gates were open, so as to run out in the lower portion of the ebb of the tide.

Q. That is down to grade 2? A. It would discharge lower than that; but I think it is injurious to the harbor to make any run of water from this territory, from this neighborhood, when the tide is as low as 2. Anything below that I think is injurious in the harbor. I have not supposed it to be desirable, except for emptying the basin for some special purpose, to carry the drainage below that level.

Q. (by the CHAIRMAN). Your area there would be about 360 feet on each gate, wouldn't it? A. Yes.

Q. And five gates,—about 1,800 square feet. A. Yes.

Q. (by Mr. MATTHEWS). Could those sluice gates be used to lower the water in the basin below grade 2? A. They could; yes.

Q. How far down,—do you know? To grade 0? A. I did not make an estimate especially for that, but if you should select spring tides, I have no doubt it could be drawn to within a foot below mean low water.

Q. I suppose it is capable of mathematical demonstration that this basin, if used as a tidal basin, could be emptied within four hours? A. Yes.

Q. I should like you to furnish the calculations. A. Yes.

Q. Is there anything else that occurs to you to explain in regard to the structure of this dam that you have designed? A. No, unless there is something about it that the commission has not clearly in mind. The gate would float in water at about half tide; that is, the weight of the gate is about equal to its buoyancy with the tide at about half tide. The gate is so designed that you may have it float with considerable force when the tide is full, and still be moved readily or have its weight in excess of its floatability when the tide runs below half tide, and still be supported by the ball bearings and surface bearings under those conditions.

Q. (by the CHAIRMAN). What is your idea, if I may ask, in going 10 feet below mean low water? A. I think that is the most effective form of sluices for the discharge of the basin. That gives a more effective form of sectional area, and the entire construction would cost less money under this form than under a wider and more shallow form.

Q. Then you design a fall from the basin, anyhow? A. Yes; I assume that during the discharge, inasmuch as the value of this tide water in passing out would be greatest in the last portion of the ebb run, it would be undesirable to begin the flow with the tide higher than about grade 6, and that we should continue to have about 2 feet fall through the gateway during the discharge of the tide; and then, from such experiments as I have made, compared with what I have known in other flumes, I think with that form of approach, and the passage away from the gates, that under 2 feet head we should have an available velocity of about 11 feet a second for discharge.

Q. (by Mr. MATTHEWS). With that velocity just below the dam, where would the stream resume its normal velocity? A. Well, it immediately begins to expand just as it passes

the position of the stop-planks, and it would check very much immediately. It would empty into water about 30 feet deep at low tide, and, while the centre of the current would show unquestionably for some distance below the structure itself, I think that there would be no ill effect upon the bottom or upon any structure that would exist there, whether this was at the site of the Craigie bridge, and the object that would be met by this current would be the freight bridge of the Lowell Railroad, or whether it were at the site suggested by the Joint Board, and the structure would be the Craigie bridge structure that would be first met by the current. The velocity would be very much less than we have had in some of our bridges under constant use.

Q. (by Mr. DUNBAR). What was the velocity you gave with a fall of 2 feet? A. I said the effective velocity would be about 11 feet a second.

Q. Where did you say the velocity would run out, to normal? A. Well, there would be undoubtedly an added velocity to the natural flow of the tide as far as the bridge, but not one that would be observable particularly.

Q. In the upper harbor there wouldn't be any increase in velocity? A. No; it would disappear before it had passed the first bridge.

Q. The first railroad bridge that it met? A. Yes; the volume of water added to the volume of water passing out on the ebb tide would be the only effect that you would gain by discharging this reservoir through those sluice gates. It would not be the effect of sluicing, as it is called abroad, which is severe near the point of discharge, but it would be adding so much volume of water to the ebb tide in the harbor.

Q. By operating this basin as a tidal reservoir and sluice gate, you don't add to the velocity of the ebb tide in the upper harbor, but you furnish the volume? A. Only as you add a certain volume to the tidal prism, which, for instance, between Boston and East Boston, would add slightly to the velocity. You add this volume to the volume that would come from other sources. There is nothing like the sluice velocity at all; there couldn't possibly be, at that distance.

Q. Have you made an estimate of the cost of this structure? A. Only for the position selected by the Joint Board, where the depth of water would be about 26 feet at low tide. In that position the whole cost of 184 feet (I believe it is) of structure would be, I think, $163,500, and that would make so much in length of the dam.

Q. That is, that is not extra cost over the embankment? A. That is not the extra cost, but it is the whole cost according to the sketches which have been made.

Q. (by Mr. MATTHEWS). Have you considered the effect of converting this into a fresh-water reservoir by means of a dam operated without sluice gates? A. Yes.

Q. Both from a sanitary and a harbor stand-point? A. Yes.

Q. What is your opinion as to the effect of the construction of a dam to be operated without these tidal sluice gates upon the sanitation of the Charles River valley? A. I think the general effect upon the community in the neighborhood would be favorable from a sanitary stand-point.

Q. Now, will you explain to the committee your reasons, in a general way, for your opinion? A. I think that basin of fresh water would be purer than the present basin, where the tide ebbs and flows and carries for a considerable length of time the amount of matter which is gathered from the flats and the side streams and from the sewers and other sources of impurity, carrying it backward and forward, and oscillating out and in until finally carried out by the predominance of the fresh-water flow. I think that the total amount of impurity which must be received by the basin under the present condition of the combined system of sewerage would have a less injurious effect upon a basin held at a uniform level and fed continually with the flow of the river, in which case the supply of floating material from the side basins would be stopped, and the amount of material which was gathered in the harbor would not be carried up on the flood tide. I think the effect on the quality of the water would be better with the dam than without it.

Q. Have you any opinion as to the actual flow of the river? A. Yes.

Q. On what is it based? A. It is based upon my experience in the discharge, month by month, of similar rivers, some of which I have measured, and upon my own knowledge for a great many years of the flow of the Charles so far as I have had occasion to make an examination of it, especially with reference to the supply to the Boston Manufacturing Company at Waltham, and my knowledge of the character of the drainage area feeding the river with its swamps and its basins, and with the character of the sloping surfaces. I have reached a rate based upon comparison with other streams which I class with this stream, which I know the discharge of; and I have here the quantities

which I used per second per square mile for a discharge for each month of the year, and if you would like to take that now, I can refer to it and give it to you. It would be a larger discharge through the summer months than has been found to be discharged by the Sudbury River, which is not of the same general characteristics exactly as the Charles and is a much smaller river. The Sudbury River has about 76 square miles, and this at 200 — I don't remember exactly, but perhaps 200 square miles more than the Sudbury basin. I will refer to that table of quantities in my written statement to the committee.

Q. Have you made any study, Mr. Shedd, of the possibility of operating a dam, such as designed by Mr. Blake or yourself, without the tidal sluices, so as not to permit the piling up of a large volume of water behind the dam above grade 8? A. Yes, to a considerable extent; that is, to the extent of taking care of the ordinary run of the river. I have not, however, made an estimate of the effect of maximum freshets with maximum tides without sluice gates. I have done that with sluice gates, but I have not done that without sluice gates. Of course I can do that if desired.

Q. Let me modify my question, then, and ask you if you have made an examination of the question that I suggested, including the use of the tidal sluice gates? A. I have.

Q. What was the result of that investigation? A. The question was presented: suppose we have a tide equal to the tide when Minot's Ledge lighthouse was carried away. That was in 1851, and, as it happened, I made measurements around Boston and Charlestown of the height of the tide at that time, 5 feet 7 inches above ordinary tides. Suppose we have such a tide as that, and the tide rises to that level. Suppose at the same time there occurs the greatest freshet ever known in the Charles River, that is, that is known since records have been made. That would be equal to the freshet of February, 1886, when so much trouble was found in the Stony Brook bed. Measurements were made with such care as could be exercised, or estimates from the records were made at that time by Mr. Stearns, and I think that I should agree entirely with his conclusions at that time. I think he found a flow of 5,800 cubic feet a second at a certain point up the river. I assume that the freshet should discharge 6,000 cubic feet a second. Now, when the tide rises below this dam and it reaches elevation 8 (which is the elevation at which it is intended

to keep the reservoir), from that time on during the rise of the tide no water can be discharged from the reservoir. During the time when that tide must rise from elevation 8 to elevation 15.58, and goes down again, the water that comes down by the freshet must be held in the basin, and will cause the surface of the water to rise in that basin. In making my estimate, for the purpose of doing it without too much elaborate calculation, I assumed that the discharge from that basin would not occur again until the water of the tide had receded to elevation 8; but to the extent that the reservoir inside rises above 8, of course, there might be discharge immediately after the tide recedes, so that it comes to the same elevation outside of the dam that it reached inside, from that time the water could be discharged, the discharge could begin. But on the assumption that the water below the dam would run down to 8 before the discharge occurred I have found the water inside the basin would rise 3.96, which, added to elevation 8, — that is practically 4 feet, of course, — would make elevation 12 on the inside of the basin, while the tide outside had risen to 15 feet and 7 inches, that is, the basin would not rise so high by 3 feet 7 inches as it would rise if the dam had not been there, — the dam would hold the tide back to that extent. The calculation which I spoke of would be somewhat complicated in the following respect. The top of the sluice gates has been fixed in my design at elevation 14. There is a certain amount of framework above that which would occupy something like 2 feet, which would carry the top of the framework to elevation 16, which is higher than the tide would rise; but there would be opportunities for water to leak through into the framework and over the top of the gates for that period when the tide was rising above 14 and falling to 14, but that would be very much less than the amount that would be discharged if the gates were opened at elevation 12, instead of waiting until the tide has reached elevation 8 in receding. So that I did not pursue it farther than that. Under those conditions the tide in the basin, the water in the basin, would rise practically to 12, or 3 feet 7 inches lower than the elevation of the tide if there were no dam there.

Q. I don't see that you have been operating any sluice gates in this calculation. A. When the tide has reached elevation 8, then I should open the sluice gates, and the sluice gates would take care of a great deal more than the fresh water, and the water would drop in the reservoir. No sluice gates nor any other gates could be operated after the

tide reaches elevation 8 until it reaches full height and comes back again.

Q. You have used the sluice gates simply to reduce the level of the water from grade 12 to grade 8 quicker than it could be reduced without them. A. Yes.

Q. (by Mr. HAMLIN). May I interrupt to ask what is the height of the top of the wall along Beacon Street? A. The grade at Charlesbank is 15.

Q. Farther up, by Dartmouth Street? A. I am not sure about that. Perhaps Mr. Jackson can tell you.

Mr. JACKSON. It is lower than 15.

Mr. DABNEY. 14.07 goes right over it. I suppose the top of the wall comes up to the top of the street.

Q. (by Mr. HAMLIN). 14 would bear out the figures you have just given? A. Certainly. I have no knowledge about the height there. I only know that Charlesbank is 15.

Q. I understand these figures are based on the fact that there are to be sluice gates that you are giving now? A. It may be with or without sluice gates, except that the sluice gates would furnish more ample means to hold the basin down low, while the tide and the freshet were gathering to the extreme height, than could be arranged without the sluice gates. And when the tide had receded below the dam, below that level of 8, then the sluice gates would allow you to draw out the reservoir much more rapidly and take care of the freshet much more rapidly. It was in that way that I answered to Mr. Matthews that I had not made the estimate accurately without the sluice gates. I had given this in the use of the sluice gates, but I did not use the sluice gates in any other way than to insure elevation 8 inside when the critical time comes, and the tide has risen on the outside to 8 and must go on to rise to 15 feet 7 inches, while a maximum freshet in the river occurs.

Q. What would be the total length of time there would be no discharge? A. I have forgotten, now.

Q. I mean approximately. A. Well, in the neighborhood of three hours up and three hours down; I have forgotten that, but I used that time; it was in the neighborhood of three hours.

Q. I understand you haven't made any figures disregarding sluice gates, to show that in those three hours, during any conceivable freshet, the storage capacity might not be overflowed? A. The storage capacity during that tide, when the water rises 3.96 or practically 4 feet, there are no gates, sluice gates, or any other gates in use. That is the

capacity of the reservoir to store water about six hours when everything is closed entirely.

Mr. MATTHEWS. If I understand it, Mr. Hamlin, the witness only uses the sluice gates to lower the water. The presence of the sluice gates does not insure the water in the basin will not rise above grade 8.

The WITNESS. From 8 up and down through to 8. The problem is the same, whether you have sluice gates or not.

Mr. HAMLIN. That is what I wanted to be sure of.

Q. (by Mr. MATTHEWS). Can you use sluice gates for avoiding even a rise of 4 feet in the basin, under those conditions? A. You can in this way: before a tide would have reached this extraordinary character, it would be supposed that the manager of that dam would anticipate a high run of tide, and especially if a freshet occurred at the same time; and if he managed in the usual way for such situations he would draw the reservoir down below 8, in anticipation, so that he would have,—he might well enough have a storage capacity of the whole 4 feet required, or more, and be ready for the period when no discharge could be made, and the reservoir then would only fill to 8 instead of filling to 12.

Q. (by Mr. DUNBAR). I understood you were to give us the capacity of those sluices for drawing off the water. Was that one of the things you were going to put in your table or diagram? A. No, I said that would be in about six hours. I will make the estimate. Mr. Matthews asked if I would give the figures. That would be discharge in about six hours.

Mr. MATTHEWS. What I asked you was, if you wanted the demonstration that the water behind the dam could not rise above grade 12.

Mr. HAMLIN. Yes, I should like that.

The WITNESS. Yes, I will give it.

Q. (by Mr. HAMLIN). May I ask you what you take as the basis of getting the flow of Charles River—what your inquiries were at the dam at Watertown? A. There were measurements made during the time of the run-off of the great storm of February of '86, for a week.

Q. Were those weir measurements? A. They were over the dam, which is, to all intents and purposes, weir measurement. But it is an estimate of the quantity of water delivered over the dam, knowing the depth of water at the dam, and the length of the dam, and those estimates were made in that way. Using that, my estimate of the quantity of water at the maximum delivered here was 5,800 feet a second.

Q. What would that be turned into gallons? A. 7.48 times that. It would be 45,000, nearly.

Q. (by the CHAIRMAN). About 40,000 a second. A. Yes, about 45,000 gallons a second.

Q. (by Mr. HAMLIN). How much a day? A. There are 86,400 seconds in a day. If I have made no errors here, there are 3,859,520,000 gallons in a day; that is, take it in gallons for the unit, 3,859 millions. I couldn't realize that figure as well as I could 6,000 feet per second.

Q. (by Commissioner DANA). Mr. Shedd, may I ask how feasible is it to anticipate the flood by lowering the water in the basin; that is to say, is the maximum flow in a freshet such as they had in 1886 right at the beginning of the rainfall? A. No; the maximum flow ordinarily occurs about four days after the heaviest of the rain has ceased, and this freshet condition grows and is telegraphed all over the country, if anything very extraordinary, a day or two before the maximum height is reached.

Q. Yes, that's it, so that it is a feasible thing to lower the basin? A. Yes; if the caretaker is negligent, half of Boston could be after him before there would be any real danger.

Q. (by Mr. MATTHEWS). Did you state that you would bring in your figures for the normal flow of the water? A. I have those here now.

Q. These can be presented to-morrow? A. Yes.

Q. Now, Mr. Shedd, is there any explanation or detail that you think would be of assistance to the committee in relation to the sanitary aspect of this case or the mode of operating this dam from that stand-point in the fifteen minutes we have still? A. Well, I have made an investigation of the amount of pollution that would occur here in the river under the ordinary flow for each month of the year, based upon my opinion as to the flow which would occur at that time and based upon the amount of population which will exist there in 1930. If the commissioners who considered the metropolitan drainage system are right in their estimate, there will be a population of a little over 5,000 people per square mile over the entire area that is now served by the combined area of sewers, which is 19.51 square miles. That would take care of the population of 101,589. In that way I have considered what the condition would be at that time when there are 101,589 people upon the territory sewered by the combined system, and overflowing at every storm that is greater than the sewers were intended to take away wholly.

Q. I suppose that calculation is predicated upon the continuance of the combined system of sewers? A. That has been the assumption, that they will. I have no idea that they will continue, but the calculation is based upon that idea of the continuance and upon the growth of the population to the extent that was estimated by the commission.

Q. Now, will you please state your conclusions? A. That I will submit in writing.

Q. (by Mr. HAMLIN). As to the Charles River, whether you consider it a torrential stream, or whether it rises slowly? A. It rises slowly and falls slowly; it is not what might be called a quick river. It doesn't approach even the Sudbury River in that matter of quick rising and falling, and the Sudbury River would hardly be classed as a quick river.

Q. I thought the Sudbury River was classed as torrential? A. Well, it is about on the line perhaps, but it is very much more rapid in rising and falling than the Charles River. There are large portions of the Sudbury basin that are rather flat and have low grounds, but, on the other hand, there are steep hillsides on the basin.

Adjourned to March 7, 1902.

TENTH HEARING.

OFFICE OF THE METROPOLITAN PARK COMMISSIONERS,
BOSTON, March 7, 1902.

The hearing was begun at 10.30 A.M., Chairman Pritchett presiding; all members of the committee present.

Mr. MATTHEWS. I believe I am requested by the chairman to state, if I can, the agreement that has just been entered into. As I understand it, it is that the hearing shall be suspended at this point, except that Dr. Henry J. Barnes is to be given an opportunity to address the committee, and that Mr. Lewis Dabney is to have the same privilege; that I am to have the privilege of making a brief statement as to the utility of tidal sluices; and that, if Mr. Pillsbury or his clients should desire a hearing as to the location of the dam, it will be given.

Mr. BROOKS. That includes all the Cambridge interests. I represent certain riparian interests on the Cambridge side.

Mr. MATTHEWS. I thought Mr. Pillsbury represented them all, but I suppose the privilege is extended to anybody who represents riparian interests on either side. I also understand that the committee will receive written data, calculations, reports and opinions from any engineer, either those who have already testified in the case or others who have not, retained by any party interested in this controversy.

Mr. DUNBAR. I did not understand that was in. We have not had that before. We have got a couple of experts we want to put in, and you have Mr. Blake, Mr. Shedd and Mr. Hazen.

Mr. MATTHEWS. Mr. Hazen on sanitation. I will state that we have three expert engineers, Mr. Blake, Mr. Shedd and Mr. Hazen. Judge Dunbar says that he has two. I suppose the same privilege would be extended to anybody else.

The CHAIRMAN. Yes.

Mr. MATTHEWS. I understand copies of these opinions are to be handed to counsel on the other side. In addition to this, the committee desires counsel to submit briefs of enumeration of points of inquiry. Then, after those briefs have been received, the committee will, with its engineers,

confer with the engineers designated by the respective parties. Does that cover the case?

Mr. DUNBAR. I think that covers it all. Conferences between the committee and the experts of the respective parties to be limited to four days, but this time may be extended by consent and agreement of all parties.

The CHAIRMAN. Better leave it in that any party who is interested who desires to submit a report may do so. I think we should receive it.

Mr. MATTHEWS. It is understood, of course, that all the information collected by the committee may be examined by our engineers.

The CHAIRMAN. Yes.

STATEMENT BY DR. HENRY J. BARNES.

Mr. BARNES. Rev. Elmer H. Capen, president of Tufts Medical School, is the chairman of my committee in regard to this matter, and I think that he should be present and be the person to be heard in regard to Tufts Medical College, and not myself.

The CHAIRMAN. My understanding was that he would prefer to send a written statement.

Mr. BARNES. I have no other interest than the interest of Tufts Medical College.

Mr. J. A. COUSENS. Mr. Chairman, there are some comparatively small interests on the Boston side of the river which have been represented for the most part at all the hearings, and they would, of course, like an opportunity to present a statement showing their position, but I think that could be done in writing.

STATEMENT BY NATHAN MATTHEWS, JR., IN REGARD TO TIDAL SLUICE GATES.

The committee will understand that Mr. Shedd has a large number of plans relating to the effect of tidal scour, and also upon sanitary questions; Mr. Blake has a great many plans and diagrams on both of the scientific aspects of this case; those we shall not present to the committee at this hearing, but they will be presented whenever the committee desires them, privately, or at the conferences which are to be held by the committee, and will be referred to in the brief which I shall submit. I shall endeavor in my brief to call attention to the evidence that we have had specially prepared for this case, in the form of plans, diagrams, calculations, etc., and, in view of the arrangement that has been entered into,

all I desire to say this morning is a few words on the subject of these tidal sluices, which are an entirely new idea, and which, as explained by Mr. Blake and as would have been explained by Mr. Shedd if he had continued his evidence, have been introduced into this case and exhibited upon the plans prepared by both those engineers, at the request of counsel, and not because, in the opinion of these gentlemen, these tidal sluices would serve any necessary purpose.

The type of sluice that Mr. Blake has designed differs from that which Mr. Shedd submits. Colonel Mansfield was not here at the last hearing, when Mr. Shedd explained his tidal gates, but the diagrams are before the committee, and he will of course understand them upon a simple inspection, Mr. Blake's gates are of the vertical type; Mr. Shedd's revolve upon pivots, if that is the correct mode of expressing it, and do not operate with a vertical lift. The discharging area is about the same, I think; possibly a little greater for the type of sluice suggested by Mr. Shedd. The time of discharge, that is, the time it would take to empty the entire basin down to grade 2, would be about the same in either case. Both gentlemen will submit to you mathematical demonstrations or calculations of the time it would require to empty the entire basin to grade 2, upon either plan. So far as the cost is concerned, Mr. Blake's estimate is considerably higher than Mr. Shedd's. Mr. Blake estimates that the additional cost of introducing his tidal sluices into the dam would be $225,000; Mr. Shedd estimates that the total cost of the entire section of the dam occupied by his tidal sluices would be only $160,000, and that, I apprehend, would indicate an extra cost of perhaps $100,000 or $125,000.

These suggestions are not made to the committee as rival propositions. They have come about simply because these gentlemen were requested (as it happened, independently of each other) to design a type of sluice which could be used for emptying the basin, or so much as it was desirable to empty, in a single tide; and the result is two different schemes or types of sluice. I care to say nothing as to the respective merits of these two plans. I will leave that matter, together with the cost, to be dealt with by the committee in the manner it sees fit. What I want to say this morning relates to the necessity for them, or the utility of them; and I desire that I may be permitted to preface my explanation of the reason why these sluices were suggested by counsel in this case, although they were nega-

tived by our engineers, by a short historical statement, which will throw some light, I think, upon the reasons why the investigation of 1894 was so inconclusive and unsatisfactory.

The State Board of Health proceeded with its report — that was the Joint Board — without consultation with anybody connected with the city government of Boston, although the idea had been first promulgated by the city, and the bill under which they acted was put into the Legislature and the passage of it secured by the city of Boston. The same thing happened also with the metropolitan water act. Those plans were promoted by the city of Boston, or the officials then representing the city, and yet in neither instance did the State Board of Health consult a single member of the city government of Boston, political, professional or legal, in the preparation of its report. The consequence was, that when the report of the Joint Board made its appearance we found that those gentlemen had committed themselves to a type of dam which was inelastic, and which would not lend itself to the possibilities of the situation, in case Mr. Stearns should be mistaken in his opinion as to the sanitary value of this basin. In other words, in the event — which we considered improbable, but which, not being professional engineers, we could not conceive to be impossible — in the event, I say, that some unsanitary condition should be created by the conversion of this natural tidal reservoir into an artificial fresh-water basin, there seemed to us (I speak for the city authorities at the time) no way provided, no reasonably practicable way provided, by which that basin could be drained quickly and converted temporarily or permanently into a salt water basin. If in any aspect of the case or for any reason the fresh-water basin turned out to be a temporary failure, it seemed to us that the dam was of such a type that the basin could not be quickly emptied, and that in that event the result might be the destruction of the dam itself, its removal, and the loss of all the money that had been put into the enterprise. We thought that no sufficient precautions had been taken to meet the layman's view of the case, to meet the possibilities of the situation; and it was for that reason that the city of Boston refused, upon request, to support the proposition of the Joint Board before the Harbor and Land Commission in 1894.

If these circumstances had not existed, if, in my opinion and that of the city engineer at the time, there had been a possibility of handling this fresh-water basin so as to obviate

all possible theoretical cause for complaint, if any such should arise, the city of Boston would have been only too glad to furnish all the money needed for the scientific investigation of the case, — that is, in behalf of the case of the Joint Board, before the Harbor and Land Commission. The city has plenty of money at its disposal for just such purposes, the public funds have been used for just such purposes, and they would have been used on that occasion, because I was myself the original suggestor of the plan, and was then as heartily in favor of the plan as I had been before and as I am to-day. But I was unwilling to commit the city and the public to a proposition which seemed to me not to meet and not to be intended to meet the possibility that Mr. Stearns might be mistaken in his opinion as to the sanitary effect of converting this tidal reservoir into a fresh-water basin.

I will say that we paid no attention to the tidal question, in so far as it would affect the harbor, the uniform opinion of the city engineers having been that the maintenance of the harbor channels was in no sense dependent upon the presence of these tidal reservoirs beyond the upper harbor; and if that had been the only objection, we should have done everything we could to have furnished scientific investigation and opinion in support of the construction of a dam of a permanent type, without tidal sluices at all. But the sanitary question seemed to us to be extremely important, and not to have been duly considered by the Joint Board; or at least it seemed to us they had not sufficiently taken into account the possibilities of the case, and had not provided for the contingency, remote but conceivable, that unsanitary conditions might from time to time appear in this fresh-water basin. That is the reason why the investigation before the Harbor and Land Commission in 1894 was one-sided, why there was no official effort made to prosecute the case for the dam, and why that investigation was a failure.

When this matter was to be re-investigated for this purpose, Mr. Storrow — and I am speaking for him as well as for myself — Mr. Storrow and I concluded that something should be designed and suggested to this committee which would obviate the difficulty that I have mentioned, and which, if possible, would remove any objection to the use of this basin as a fresh-water reservoir upon sanitary grounds. Accordingly, we instructed our engineers to design, for the information and use of the committee, a dam so constructed that the entire basin could be emptied in a single tide, or in one or two tides.

Our engineers, as has already been stated by Mr. Blake, do not believe that any such scheme is or ever will be necessary, and they are unable to give the plan their scientific or professional approval, for the reason that they are not willing to admit the possibility that it will ever be used for the purpose for which it could be used as designed. Mr. Blake has, however, provided in his dam larger openings than the State Board of Health dam had, apart from the tidal sluices. His total discharging area, for the regulating ports alone, is 30 per cent. in excess of that proposed by Mr. Stearns, and he has also a wasteway. Furthermore, the cross-section of his lock is greater; so that the basin could be emptied without tidal sluices better than could have been done with the dam proposed by the Joint Board in 1894; but without those tidal sluices Mr. Blake's basin could not be emptied in a single tide. We then asked him and Mr. Shedd to insert, for the consideration of the committee, a section of this dam so constructed and fitted with tidal sluices that the whole content of the basin can be let down in a single ebb tide.

As to the necessity for this proposition, that, again, and all the other scientific questions in the case, we leave to the committee. We have no opinion of our own, and are entirely content to rely on the judgment of this committee. If they think these tidal sluices would serve any useful purpose, — even the mere purpose of quieting the community and removing reasonable cause for apprehension among laymen, — we submit that the sluices ought to be incorporated in the plan. It is sometimes, Mr. Chairman, well to exercise an excess of caution. This proposition is plainly one presented by us *ex majore cautela*, and not because it is scientifically a necessary thing. The committee may possibly reach the conclusion that tidal sluices are necessary. In that event, or in the more probable event that they should be determined to be unnecessary, but useful from the public stand-point, then we suggest that some type of tidal sluice, some machinery of that kind, be recommended by the committee in its report, — not with special reference to the possibility of operating this basin as a tidal reservoir for some supposed benefit to the harbor channels (although it might be operated for that purpose, as was pointed out by Mr. Blake the other day), but chiefly for the purpose of emptying the basin in a single tide, if that should ever become desirable from a sanitary stand-point. That is all I have to say upon the question.

Mr. PILLSBURY. As I have not heard everything that

has been said here, I should like to ask whether anything has been said or suggested by the proponents upon one rather important question, namely, upon whom or what it is proposed to charge the cost for this dam. Is it proposed to charge it upon the State, the city of Boston, or the metropolitan district, or upon somebody else? Has that question been discussed?

The CHAIRMAN. The resolve provides that this committee, should it find it wise to recommend the erection of the dam, should make an estimate of its probable cost, and assess, according to their judgment, the charges against such communities, such cities, as may be benefited thereby, and in such proportion as they may think it advisable; but nothing has been said before the committee on that matter. The committee adjourned until 10 o'clock on Thursday, March 13.

ELEVENTH HEARING.

METROPOLITAN PARK COMMISSIONERS' OFFICE,
BOSTON, March 14, 1902.

The hearing was begun at 10.30 A.M., being postponed from March 13, all members of the committee present.

STATEMENT BY DR. HENRY J. BARNES.

Mr. Chairman and gentlemen, as a member of a committee of the Faculty of Tufts Medical School, I would say that Mr. Capen, who is the chairman, would be here if you desired it, but his statement would be no more than what is embodied in the communication which your Board already has on file. Dr. Williams, a member of the committee, has been here once, and was prepared to be here yesterday, but is unable to be here to-day. He will come if it is necessary for him to do so. His testimony would be in the nature of personal observations of the sewage flow into the Charles River seen from his house on Beacon Street, and to the effect that frequently its influence extends halfway across the river. He has observed the bar or bars just below the bridge in the Fens on Stony Brook, where he had seen ducks standing on the bars clear across the channel, indicating a depth of water not over six inches, although next the island there was at the time considerably greater depth in the channel where the water was flowing, — it was perhaps a foot or a foot and a half deep, and the same width; that he had observed frequently the St. Mary's Street overflow; and I think that would embody substantially all that he had to say. He would come and testify to these facts, if you desire.

I should say, in behalf of the committee as a whole, that it does not oppose the building of a dam, and it would welcome anything that would improve the appearance and condition of the Charles River basin; but that it is very solicitous lest attempted improvements might be made which might not prove such; that is, if the dam were erected in harmony with the report of the Joint Board, made in 1894, it has very grave fears of the effect on the Fens basin as a consequence of the stagnation of water and sewage there. But if a folding dam, as now proposed, were erected, which

might be taken down as often as required, it feels the objections would be obviated. If a dam such as has been proposed, or was proposed at the last meeting by Mr. Matthews, — a dam provided with sluiceways that would permit the drawing off of the dirty water of the Fens as often as might be necessary, we would make no objection, because we feel the condition of the Fens would not be made any worse than by the present provision. But, assuming you have not arrived at any such conclusion regarding the necessity of emptying the basin, I shall address myself to that aspect of the case.

The Medical School is about four hundred feet from the outlet of Stony Brook into the Fens. In regard to the complaints relative to the Fens basin, I have knowledge of a complaint which was made very generally throughout the Back Bay district something like eighteen years ago, at the time of the constructive work there. There was a public outcry, and many communications appeared in the newspapers at the time, complaining of the odors from the basin.

Q. (by Mr. Matthews). What date was that? A. It was eighteen years ago.

Q. When the Back Bay Park was built, you mean, — 1882 or thereabouts? A. Yes. Mr. Wightman, the city engineer, replying to these communications in the papers, stated the trouble was due to a low run of tides in the Charles River, and he had been unable to flood the basin as had been arranged for; that is, the scows which were doing some dredging there would not float unless the water was maintained at a certain level, and he was unable to flush the basin, but he thought the remedy would be available in the course of a week; and such was the case — it was remedied when the spring tides were high enough to flush the basin.

Since that time, every year, I should say, unless it might have occurred in a year when I was absent from the country, complaints of that basin have been common; that is, people passing in the vicinity of the Fens basin have found it smelling offensively, and nearly all the time an offensive appearance of the water. For the past ten years I have been in the habit of visiting that locality sometimes every day, sometimes twice a day, for periods consecutively. I have visited that place three hundred or four hundred times during the past ten years. I have never failed to observe a sewage discharge in time of any material fall of rain, either occurring at the brick gate house on Stony Brook or from the main channel above the brick gate house.

A year ago my attention was first called to the shoal that has occurred below the bridge. I observed the ducks standing on the shoal. What I have to say confirms what I said Dr. Williams would say in regard to the matter, and I need not go over that. But I should add, since the flood of ten days ago in Stony Brook the bars have been materially carried away. The channel that was perhaps one to one and one-half feet wide a year ago, when I observed it, is ten feet wide and perhaps a foot or two feet deep; but I am informed that beyond this particular bar, about twenty feet farther down the river, ducks have been observed standing in the middle of the basin when the water was about at grade 7. It is intended to maintain it at grade 8, but a certain amount of water each day is drawn off and a certain amount of tide water let in, so there are times when it is not above grade 7.

In regard to the Charles River basin, this pamphlet was sent around to the physicians on the Back Bay prior to the signature of the paper petitioning for this improvement. I do not know, however, as that was the fact, but I think the representations contained were presented to those gentlemen who quite generally signed the petition. I would have signed it had I been asked, on the representations of a folding dam, notwithstanding the pamphlet contains some quite serious errors in regard to many statements.

First, the statement that the folding dam on the Thames is "near London." It is about ten miles above London, and near the head of tide water. It does not interfere with the tidal flow, and it is, relative to London, about where our Riverside is to Boston, about ten miles distant; and I think that pictures as inspiring as those contained in the pamphlet could be taken on the Charles River at Riverside.

Another statement which I should challenge is on page 9 of this pamphlet. I will read the paragraph and then state my objections: "Another change which has taken place since 1894, and which has a direct bearing upon the proposed dam, is the construction of the metropolitan intercepting sewer, which has removed from the river all the sewage of Waltham, Watertown, Brighton, Newton and practically all the sewage of Boston, except the small amount emanating from the houses on the water side of Beacon Street."

You have before you the testimony of the engineer of Newton, who stated that one-third of the year the sewage is flowing into the basin at St. Mary's Street; and my observation of that flow, although not justifying any such

broad statement as that, would tend to confirm what he has said. I have observed the flow five and six days after a storm, — not, however, at high tide, because I was not able to observe the flow at that time, the water being above the outlet; but whenever the water was low enough to see, I have seen it flow from five to six days after the cessation of the storm. So that I think such an observation as that is positive proof the sewage has not been withdrawn from this district, — the sewage discharge into the Charles.

Regarding the statement of Dr. Richard Cabot in relation to malaria, I coincide with the views which he expresses regarding the probabilities of this basin, if dammed permanently, not being a mosquito-breeding area; but I fail to find in his statement any consideration of the conditions in the Fens, where the water is much shallower, where the basin is quite narrow, and consequently not subject to the wind disturbance that the broader basin would have. I can't understand why this would not be a favorable mosquito-breeding territory.

I live opposite a sewer overflowing at Hereford Street, and have had a great many opportunities of observing the frequency of the overflow there. In 1893 I attempted to record the number of times the sewage overflowed into the basin from that sewer. I was away four months of the year, but during the eight months in which I kept a rather imperfect record the frequency of times was either forty-three or forty-six. I was unable to determine the length of time the flow continued, because oftentimes the water was far above the level of the sewer, and the turbid condition made it impossible for me to see whether the sewage was flowing or not; but I have seen it flowing there, every time the tide was low enough, often for four or five days at a time, after a storm. Very often I have observed, after a comparatively slight rainfall, from my chamber window, the influence of the sewage halfway across the basin. I was able to determine that pretty accurately, because the pier of the drawbridge of Harvard bridge is about in the middle, and I could see the line of demarcation separating the sewage-polluted water from the purer waters on the Cambridge side. I have frequently, when I have observed this, been across Harvard bridge, to see if I was deceived in the appearance of the water there by either shadow of the clouds or shallow water; but have always been able to see that the water is very much purer on the Cambridge side, where the flats have been dredged and where there is an insignificant amount of sewage flow, in my estimation, compared with what goes in on

the Boston side. But it is possible that the sewage from the Binney Street sewer, which carries most of the Cambridge sewage into the Charles River, appears on the Boston side, that is, it does not flow directly up on the Cambridge side, but is carried up by the currents on the Boston side. This I am not able to state positively, but that has suggested to me the reason for the comparative purity of the water on the Cambridge side and the polluted appearance on the Boston side in times of storm overflow.

I have some notes here of sewage flow, which, although not conclusive, suggest the great importance of accurate knowledge as to the volume of sewage discharged from the Boston side, which I maintain has not yet been presented to you.

In 1901, on the 4th of April, after a rainfall of .09 of an inch, at 4 P.M., sewage was flowing from the Hereford Street sewer. I took Dr. Prince there, who lives close by and who is the leading signer of the petition asking for this improvement, and he was amazed at the volume and the appearance of the sewage, having had no previous knowledge of it, although he has lived close to it for a good number of years.

On the 7th of April, no rain since early morning, at 1.30 P.M. sewage was flowing at the St. Mary's Street outlet of the metropolitan system (Charles River sewer).

On May 3, eleven hours since rain, sewage was flowing at Hereford Street.

On May 26, at 1.45 P.M., thirty-six hours since last rain, sewage flowing at Hereford Street and St. Mary's Street. I went up to Stony Brook at the time, to see if there was any flow there. The water was pretty turbid, but there were very few fecal masses floating in the water, so I concluded no sewage was flowing in at that time.

On March 6, 7 and 8, 1902, there was no rainfall, but some snow melting in the streets. For these three days sewage was flowing into the Fens from the Stony Brook outflow.

On March 9, last Saturday night and Sunday, there was a rainfall of .57 of an inch, according to the Weather Bureau's report in Monday morning's paper. Monday afternoon, twenty-four hours after rainfall, there was a flow of sewage at the Hereford Street sewer, and this was not diluted sewage. There was no snow in the city, possibly some little in the back yards on the north side of the houses; but I took particular care at this time, in my walks about the Back Bay, to see if there was any storm water or melting snow flowing into the catch-basins. There was no indication of

it, and yet, thirty-six hours after the rainfall, the sewage was flowing undiluted from the Hereford Street overflow of the common sewer near my house. The volume flowing there I was able to estimate with some degree of accuracy, as the tide was very low at the time. I should say the stream was about six inches deep and about four feet wide; and I should furthermore say that it probably embraced all the dry-weather flow of the district tributary to the sewer.

On Tuesday evening, forty-eight hours after the rainfall for that period (.57 of an inch), I went there with Mr. Willard Sears and Mr. Moses, and the sewage was still flowing, undiluted.

During this period, thirty-six hours after this rainfall, I observed in the morning of March 11 a great volume of fecal matter floating on the top of this Hereford Street sewage overflow. It was about a foot wide, and the scybala were about as close as they could be carried. I went down as far as Gloucester Street, — the tide was running out, — and I could see these floating masses going down next to the bank wall. I stayed there about five minutes, and this flow continued during that period; it was undiluted sewage.

On the 12th of March the gates were closed, so that it was not an accidental opening of the Hereford Street gates; they closed of their own volition on the 12th of March.

In regard to Stony Brook during this period, it was discharging Monday, Tuesday and Wednesday, but not on Thursday, March 13, yesterday; that is, there was a flow of sewage in Stony Brook for ninety hours after a rainfall of .57 of an inch on Saturday night and Sunday.

This morning, after a rainfall in the preceding twenty-four hours of .08 of an inch, there was a distinct line of demarcation separating the sewage-polluted water of the Charles from the purer water on the Cambridge side, the line extending nearly to the pier on Harvard bridge, — it was not quite to the pier. I went to see if the Hereford Street sewer was overflowing at that time, and it was not. The tide was running in at the time, so it could not have come from the Fens basin, which carries a good deal of very turbid water at this time of the year. It must have come from sewers below Hereford Street.

That includes all the notes I have to present on the subject of sewage flow, but I would say in connection that I have observed these conditions long before the Joint Board made its report, and a great many times since; and that a dam such as proposed by the Joint Board, a permanent dam, which would only change the level of the water a foot

with each tide, would be insufficient to take care of this matter; besides, for the Fens no provision was made in the Joint Board's report.

I think it is within the knowledge of every person that stagnant water, if containing even a small amount of matter which is capable of decomposition, often undergoes a putrefactive change, and is very liable to smell. I have noticed this in many mill ponds during my life. It was especially noticeable in basin No. 3 of Boston's water supply before the excavation of this basin, which I described at the time as smelling of the pig pen, — and which expression Mr. Remsen afterwards used in speaking of the basin, — due to the decay of algæ which grew luxuriously in it. This basin had little or no sewage, but the fertilization of the water by the organic matter contained in the soil was sufficient to sustain a very luxurious growth of this vegetable matter, and when it died and decayed it gave rise to the offensive smells which were generally complained of in Framingham.

I maintain that the Fens basin would present similar conditions to this, in that it would be practically a stagnant basin, with very little movement of the water; that the bottom of the basin is covered with filthy matter from deposits of sewage; that the adjacent land is saturated with organic matter capable of putrefactive change; and that, if the water is not kept moving, the odors will be more perceptible than they are now. I consider it absolutely necessary that this basin should frequently be flushed with pure water, or with as good water as can be obtained. At the present time I am informed that it is flushed twice a day, and this barely keeps down the odors. It is not complete. There are a great many periods when the Fens smell offensively. On two occasions, possibly three, I have known the oxygen to be completely exhausted in this water, as indicated by the death of the fish there. I have seen thousands of fish piled up on the shores, and eels coming to the surface to breathe air, because they could obtain no oxygen from the water. Mr. Blake has already stated that it requires an abundant supply of free oxygen in the water to provide for the decomposition, the elimination of gases set free by decomposition. In the Fens basin, as a stagnant basin, there would not be sufficient movement of pure water to provide a sufficiency of oxygen. Furthermore, if a current were created in that basin by a pump, as now proposed, I can hardly conceive of one of sufficient capacity to create a current throughout that basin. The shore lines are very irregular, there are deep indentations or bays and many shallow places, where it seems to me

a current admitted at the Beacon Street sluiceway would not reach. It would traverse some part of the basin, but there would not be a uniform sweep of the whole basin. It would leave in those places stagnant water, where the bottom is covered with decaying matter, and where the sewage of Stony Brook would leave a good deal of matter in solution. I think it would be a cause of great offence if there were not provision for completely emptying the basin as often as necessary.

Furthermore, the condition of the Fens basin above the Brookline Avenue gate house: it is offensive at times; it is filled with algæ, which gives rise to that effect. If the basin below is converted into a similar basin, I do not see why there should not be the same conditions of growth of algæ in the basin below as exists in the basin above the Brookline gate house. There is abundant authority for the statement that one per cent. of sewage discharged into stagnant water will do more harm than one hundred per cent. of sewage in motion.

I had a conversation some years ago with Alfred Carpenter, the celebrated English sanitarian, and he said to me that he believed sewage could be conducted any distance without any offence if it were kept in motion; that a sewage discharge might be fifty miles from the point of its production without creating any offence in transit, provided the sewage were kept constantly in motion; for it is in stagnation that sewage decomposes, where the micro-organisms, which do the work of decomposition, have an opportunity to colonize. That this decomposition with an abundant supply of oxygen is not an offensive process is known well to all; but the experience of the world is, that where sewage is discharged into stagnant water invariably offence occurs.

If a dam is to be built on the Charles River at Craigie bridge, impounding this wide and large volume of water, I desire to call your attention to the fact that the movement of the fresh supply of water from above would not flow uniformly toward the dam, covering the whole area of the basin, but would be conveyed in channels, which no one can locate in advance. The channel might be in the centre or on either side, the Boston or the Cambridge side, but where it would be is impossible to state. At the present time, with the great volume of tidal flow there, there is a very distinct and noticeable difference in the movement of the water in one part of the basin and another. For example, just above the Beacon Street sluiceway, with the tide run-

ning out at one foot below high tide, there is almost complete stagnation; that is, the scum and the grease which comes in from the overflow of St. Mary's Street is practically stopped at that point. Beyond the Beacon Street sluiceway the current takes a course next to the wall, and there is a very rapid movement of the water below the sluiceway, while above it is practically stagnant.

Q. (by Mr. DUNBAR). Are you referring to Charlesgate East? A. Yes. Now, with the basin dammed, these areas of stagnant waters might be opposite a sewage discharge. Sewage would there be deposited, it would accumulate on the bottom and be subject to putrefactive change, decomposition, and give great offence; therefore it seems to me provision should be made in the dam to empty the basin.

Furthermore, I would call your attention to the clam beds in the basin. Last fall and up into the middle of the winter half a dozen to a dozen men were there at low tide, digging clams, procuring boat loads and carrying them off for sale. I believe the Board of Health stopped it. The great numbers of clams there of course will be destroyed by the conversion of the basin from a salt-water into a fresh-water basin, and even if there were no sewage, they would cause some trouble for at least a period of time. But that would finally disappear, and, if the sewage were withdrawn, I should say that the basin would be in a salutary condition.

In confirmation of these views on the purification of sewage in running water, I should like to refer to Professor Sedgwick's report on the Pittsburg problem, 1899, pages 16 and 17, under the title of "Running water purifies itself." He says the process is incomplete and insufficient. "This purification is largely if not wholly by dilution, and the elements are only scattered by this process. Destruction and sedimentation is more complete in standing water." Further, he quotes: "As long ago as 1874 the River Pollution Commission of the British government, after careful investigation, concluded there is no river in the United Kingdom long enough to secure oxidation and destruction of any sewage which may be discharged into it, even at its source. The agencies are more complete in standing than in running water." I desire to refer you to the fact that the Thames is about three times as long as the Charles River, and that those eminent authorities consider that the sewage cannot be discharged with safety into running water.

For these reasons I maintain that the references to the State Board of Health's report for 1890, page 789, are not valuable for the purposes of this hearing. Mr. Stearns

practically says this in subsequent pages. On page 791 he writes: "All of the foregoing relates to the pollution of the water itself, as if the sewage emptied into a stream of unvarying volume, flowing with sufficient rapidity to prevent deposits. If, instead, the sewage is turned into a stream where it is ponded by a dam, or if there are ponds on the stream below the point of discharge, the solid particles of the sewage may accumulate and decompose, giving off offensive gases. This is more likely to occur if the deposits are covered with foul water, in which the dissolved oxygen has been used up." Furthermore, Mr. Goodnough, reporting on the Neponset meadows in 1897, speaking of the floating masses which he and others had observed there, says: "Their presence there is due to large deposits of putrescible matter in the bottoms of the mill ponds. . . . In warm weather it is covered and bound together by oscillaria, then floated by bubbles of gas resulting from decomposition of the organic matter. . . . In the pond of Hollingsworth and Vose, patches of half an acre or more appear at times."

The basin would prove a culture field for vegetable growth more favorable than under present conditions, I maintain, as a consequence of the elevation of the temperature of the water. I believe if it were land water solely and not tidal water, there would be an elevation of from six to eight degrees in the temperature of the water of this basin, and this might be just enough to establish and maintain a luxurious growth of algæ, which causes very serious offence when decaying. So that my position in this matter is that you should be absolutely sure of the volume of sewage flowing in from the Boston side, before recommending the construction of such a dam as has been proposed.

Q. (by Mr. Turner). Dr. Barnes, how often do you think it will be necessary to empty the basin in order to avoid offence from sewage? A. Without any knowledge as to how much sewage goes in there, it is a very difficult thing to state. I should say that during the summer months, the hot weather, it would be necessary to empty the basin about every day, chiefly because of conditions in the Fens.

Q. If it were necessary to empty it every day, the object of the dam would be lost, would it not? A. To such an extent as the basin was emptied.

Q. From your observations, do you think the quantity of sewage entering from the Boston main drainage works is greater or less than on the opposite side, — Cambridge? A. I think it is infinitely larger. There is hardly any com-

parison to be made between the volume on the Boston side and on the Cambridge side; and this because Boston's intercepting system was built with special reference to Boston, while the Cambridge system was built with reference to the north metropolitan district. Since the addition of the south metropolitan system to Boston's system, something like four hundred miles of sewers have been added to the original system, a large part, to be sure, in territory that has the separate system; but many have been built in Boston and Brookline on the combined system, and this has overburdened our present system.

Q. With reference to the changing of the sewer systems from the combined to the separate plan, did you at one time advocate such a change as that? A. More than twelve years ago I read a paper before the Suffolk District Medical Society, urging that this be done, and I have the paper here.

Q. You were in favor of the separation? A. Most certainly; I think it is absolutely necessary. I thought so at the time, and I predicted just these conditions in the Charles River as a consequence of continuing the construction of the combined system, and the addition of territory to be provided for.

Q. Do you consider that any feasible separation of those systems can be made with reference to the Boston main drainage system? Is it practicable to separate them, for instance? A. I think it is, in course of time.

Q. In the course of how long a time, and at what expense, roughly? A. Well, I couldn't estimate, I should say it would be millions, for it would practically be duplicating the present system of common sewers.

Q. Without the practical reduplication of the main drainage system, the separation couldn't take place? A. I do not see how it could.

Q. Do you think it likely there would be any such separation? A. I should think not, — not immediately.

Q. Do you think that the maintaining of a constant level at grade 8 would have any effect with reference to the breeding of mosquitoes in the basin, — in the basin itself or in the Fens basin? A. I think in regard to the basin itself Dr. Cabot is substantially correct in relation to that matter, — it would not be a mosquito-breeding basin.

Q. How about the waters adjoining in the lowlands? A. The water in the Fens I think would be a mosquito-breeding place, more so than it is now, because salt water is admitted

to the Fens basin very often, and I don't think mosquitoes breed in salt water, — at least, I have no knowledge they breed in salt water; I do know they breed in fresh water.

Q. There are now in warm weather many mosquitoes in the Back Bay? A. It is a question what you mean by a good many. Some years there seem to be a good many and some years a very few.

Q. Have you given any attention to the progress in malaria down the Charles River at Newton and elsewhere? A. I have read the reports on the subject. I was asked in relation to the matter at the former hearing before the Harbor and Land Commissioners.

Q. Have you formed any opinion as to whether the maintaining of a constant fresh-water basin at grade 8, for instance, would have any effect as regards the exclusion of malaria? A. I think that the profession is completly satisfied with the experiments in regard to the mosquito being the intermediate host of malaria, and that maintaining the basin at grade 8 would not make it a mosquito-breeding basin. In the Fens I should say it would be mosquito breeding.

Q. Not in the basin itself, in the exposed portion, but in the Fens you think it would be? A. The water is very shallow there, there would be very little disturbance of it, it is to be fresh water instead of salt; and I think it would be a very favorable place for mosquitoes to breed.

Q. The kind of mosquitoes that are presumed to transmit malaria? A. I should presume so, because in the Charles River, above the Watertown dam, at the time of the hearing in '94, there was quite an epidemic of intermittent fever. It did not extend below the dam at that time, except two or three cases in Cambridge, attributed to some excavations made in the manufacture of bricks. There was stagnant water there. My answer to the question at that time was, in view of the fact that we didn't have malaria in Boston and that they did have it above the Watertown dam, it would be a mistake to convert the lower part of the river into the same conditions as existed above the dam; I thought it would be a hazardous experiment.

Q. You spoke of the overburdened condition of the Boston sewer system. You understand about the high-level sewer that is being proposed for the purpose of relieving this present situation? A. I do, sir.

Q. That the commission in charge of that propose to have this large enough to produce about the same conditions on

the Boston side as prevail on the Cambridge side? A. I have read something to that effect.

Q. Do you think there is any doubt to be cast upon that plan, the size of the sewer, etc.? A. I shouldn't wish to criticise; I am not an engineer; I would make sure that it would do all the work.

Q. Yes. It is our duty, I suppose, to look into that matter and find out if it is large enough to do the work, — our engineers would report. And then about the plans for the Fens, — the suggestion made for getting a current by pumping. As I understand, the present current is only made by a little of the tide rising in through a conduit. A. I don't know what you call a little. It is enough to change the level of the water eighteen inches between tides; it is not sufficient to keep the Fens in the condition they ought to be in.

Q. I understand the Fens are not at present in the condition they ought to be in; something must be done. I believe that is understood. I was going to ask one other thing about the mosquitoes — I see that the United States Agricultural Department in their report suggest that one of the remedies for the mosquito is to introduce fish into any basin. A. I have some basins of my own in which I maintain fish.

Q. So that, if fish were properly maintained in the Fens, that would — A. I think it is possible to limit the number of mosquitoes, but I don't see how it is possible to maintain fish there, in the present condition of the water.

Q. If we had fresh water there, and a current — A. I don't see any prospect of diminution of the sewage flow there.

Q. Of course I suppose that must be taken care of. A. Nor do I see any prospect of removing what has collected on the bottom, which seems to me a very important matter. A deposit of fecal matter has accumulated, which is undergoing decomposition at the present time.

Q. Irrespective of the dam, that ought to be cleared out now, oughtn't it? A. I think some remedy should be provided for it.

Q. (by Mr. MATTHEWS). Did I understand you to say that the flats were visible at grade 7 back of Hereford Street? A. No, sir.

Q. Where was the point where they were visible when the water was at grade 7? A. It was in the Fens, below the bridge.

Q. In the Fens itself? A. In the Fens itself, below the bridge, on Stony Brook.

Q. Do you think you are correct in saying there is no tidal rise and fall at the Richmond dam? Can you refer the committee to any authority on that point?

The CHAIRMAN. The committee has the complete report from the Thames Conservancy Board. The dam is a half-tidal dam, and keeps up a head of five feet nine inches at low water. Extreme tide at Richmond is thirteen feet eight inches; mean tide about ten feet; tidal flow above the dam is five feet nine inches; and the basin formed by the dam is about four miles long.

Dr. BARNES. I know Shirley Murphy, the health officer of London, told me he esteemed the tidal flow of the Thames essential to taking care of the storm sewage flow. What I mean is, there is not much tidal flow above the dam at Richmond or before the dam was erected. The dam hasn't made a material difference in the volume of the tidal flow near London.

Q. (by Mr. MATTHEWS). In regard to the sewage discharged from the overflow outlet, I gather from your statements that in your judgment the harm is done by what you call the dry-weather flow of Stony Brook, rather than by the storm flow. A. I think both. I should say that the same amount of sewage is produced in time of storm as is produced in dry weather; and, although it is more diluted in storm weather, yet the whole volume produced during that period gets into the basin and settles there.

Q. Isn't there accumulation at the bottom of Stony Brook and in these catch-basins and elsewhere, what you call the foul or dry-weather flow, which goes off in the first fall of rain? A. I never noticed any perceptible difference in the character of the sewage one hour after the beginning of the flow or twenty-four or forty-eight or sixty-four hours after. That is, the amount of fecal matter, or the number of floating pieces of fecal matter, does not seem to vary.

Q. Now, as to this morning's observation, — when you took that observation, the tide was coming in? A. The tide was coming in.

Q. And the objectionable matter in the stream might have come up from the house drains along the house side, — the Beacon Street side of the river? A. Not sufficiently for that purpose. The house drains on Beacon Street are a very insignificant factor.

Q. There are a thousand people there, aren't there? A.

Yes, sir. The total volume probably amounts to 30,000,000 gallons per year, but that is insignificant, compared with the amount that flows in during storm overflows of the common sewers.

Q. On what do you base your opinion that the temperature of the water would rise from six to eight degrees? A. I think there was testimony introduced before the Harbor and Land Commissioners of actual observation of tide water at 68° temperature and that the water above the Watertown dam was 74° to 76° temperature.

Q. Where in Boston harbor do you find a temperature of 68° now at the present time? A. I suppose these observations were made in reference to the summer months only.

Q. Yes, but away down the harbor? A. I don't understand so at all. I understood the observations were made at Harvard bridge.

Q. Sixty-eight degrees at Harvard bridge in summer? A. Sixty-eight degrees at Harvard bridge in summer.

Q. Those who have been in swimming there, or tried to, could correct that statement. But you don't make it on your own observation, — you remember some testimony? A. The testimony before the Harbor and Land Commissioners.

Q. But 68° is about the coolest you ever get the sea water at Boston Light, isn't it, in summer? A. I don't know about that.

Q. It certainly couldn't be as low at Harvard bridge as it is at Boston Light? A. I think these observations were made by Professor Porter of the Institute of Technology.

Q. I understand you think that the basin might have to be emptied once a day in summer, you added particularly on account of the Fens; and in reading over your testimony before the Joint Board, it seems to me you dwelt particularly on the condition in the Fens as being the most serious problem to meet. A. Yes.

Q. They do not empty the water in the Fens once a day now, do they, or anywhere near it? A. No, but I think that if the Fens were fresh water it would be more objectionable than salt water, under the same conditions.

Q. The water is now turbid and offensive, is it not? A. Yes, nearly all the time.

Q. You say the present Boston sewer system is overloaded, but you do not state, — you haven't the figures in reference to the overflow of sewage into the river? A. I don't think anybody has. I have read the statements presented here,

but they seem to be based on office calculations, and not on actual observations or by clocks set in sewers, which seems to me to be necessary in determining the facts. The assumption that there is produced 75 gallons of sewage per capita in the city of Boston seems a very questionable assumption. The same assumption was made at a time when we were consuming a little less than 100 gallons of water per capita. I understand now that there is about 117 gallons per capita consumption, so I should say it would be something more than it was when 100 gallons were being consumed. No consideration is given to the possibility of some of the sewers leaking, ground water, in those computations. That may be quite an important matter, in view of the fact that we have a great many old sewers in Boston which were constructed many years ago, and which may admit considerable ground water. The pumps at the Cow Pasture have been used as a basis of calculating the volume; but I understand up to a very recent time very little reliance could be placed on them, on account of slipping, sometimes measuring 65,000,000 and other times 75,000,000 per day. The basis of measurement on pumping capacity is fallacious.

Q. You have not taken into account the changes to be made in the Boston system by the operation of the high-level metropolitan system? A. I have considered them.

Q. And of the other changes to be affected by the Dorchester system, now building? A. I have considered them, and I have information that the growth of the present sewerage system of the metropolitan district is so rapid that at the time the high-level system is put in operation it will not materially relieve the Charles River valley sewer, — only three per cent., or so.

Q. It will take the whole of it, won't it? A. It will take the whole of the dry-weather flow, but not the storm flow, — that is, I am stating this on the authority of somebody else.

Q. (by Commissioner Dana). Will you state on whose authority it is? A. I should like to ask his permission, before making that statement; it was private conversation.

Q. Based on the authority of some engineer who has really studied into it? A. Yes, two engineers of distinction.

Q. (by Mr. Matthews). One further question in regard to the malaria that appeared on the Charles River above the Watertown dam some years ago. Has there been much complaint lately? A. No, I think not.

Q. That was a sporadic attack, was it not? A. Hardly sporadic; I think there were between 500 and 1,000 cases.

Q. How long a period did they cover? A. Two or three years. The Board of Health has given complete reports on it.

Q. There had never been any before or since? A. There had been, one hundred years before.

Q. But since this last outbreak there has not been any? A. Malaria has practically disappeared from Massachusetts, I think.

Q. Isn't it a fact that wherever you find the combination of swamp and Italian you find malaria? A. I don't know.

Q. Has your attention been called to that, in the town of Hamilton, for instance, in connection with the Italian camp? A. No, sir.

Q. You think in substance this dam ought to be provided with some means of emptying the basin? A. Yes, that is all I should ask for. I make no objection to a dam with the possibility of emptying the basin in one or two tides.

Q. You suggested that the commission make sure that the tidal sluices are large enough to do that?

Q. (by Mr. PILLSBURY). I observe in summing up your conclusions you refer to the dam provided at Craigie bridge. Did you make any distinction between a dam built at Craigie bridge or one built 650 feet away? A. No, sir.

Q. You think it would be necessary to flush the basin daily during the summer; how long a period would you cover during the summer? A. That would be impossible to determine, because some summers the weather is cool, the climate is cool, and it would not require it as frequently as in a long period of hot weather. I don't know as it would require to be emptied every day.

Q. Of course the character of the season would affect it, but do you think it would be necessary during three or four months? A. Yes, sir; a little more than that. I should say during May, June, July, August and probably September.

Q. Five months? A. That is the average season. I would not state positively it would be every day, but it would be frequent.

Q. Oh, no, but the character of the season would affect it, of course. I only wanted in a general way what you had in mind.

STATEMENT BY LEWIS S. DABNEY, ESQ.

Mr. Chairman and gentlemen, I am grateful to the committee for giving me an opportunity to state the position of the people on Beacon Street, in regard to this project, because since the project was revived, something over a year ago, it has been very much and very constantly misrepresented. In 1894 the Joint Board, as it is called, which had received authority under an act of the Legislature, passed in 1893, chapter 475 of the Acts of 1893, to investigate the sanitary condition and prepare plans for the improvement of the beds, shores and waters of the Charles River, between Charles River bridge and the Waltham line on Charles River, and for the removal of any nuisances therefrom, made a report which recommended a dam, as set forth in the report of 1894. Mr. Storrow has said that the investigation before the Board of Harbor and Land Commissioners, which occurred subsequently, was practically an *ex parte* hearing; he has labored to convince you of that fact. I shall have something to say about that contention later; but I want to call your attention to the fact now that this act of 1893 contained no reference whatever to a dam, there were no public hearings, we never knew there was any dam in contemplation, nobody was heard on the subject, as Mr. Matthews has told you, in behalf of the city of Boston, and this project was suddenly sprung upon us in 1894. It was a proposal which involved a radical change in the conditions under which we were to live. It was a proposal to substitute for a salt-water basin, with an inflow twice a day of 600,000,000 cubic feet of salt water, a stagnant fresh-water basin, which shall not be emptied oftener than once in eighteen days, or some such thing, — the water in which was not to be renewed oftener than once in eighteen days, except on great emergencies. What were we to do? We got together and consulted, and appointed a committee. That committee was composed of the late Mr. George O. Shattuck, who died on the 4th of February, 1897, Mr. Charles Head and myself. When Mr. Shattuck died, in 1897, he was succeeded by Mr. William Caleb Loring, who on Sept. 7, 1899, was appointed a justice of the Supreme Court of Massachusetts; and he was then succeeded by Mr. Howard Stockton; and the committee is now composed of Mr. Head, Mr. Stockton and myself, — Mr. Head and myself having been on it from the beginning, in 1894.

We consulted experts; we thought we needed advice. We consulted Col. George E. Waring, Jr., who, I believe,

had a reputation which was excelled by no one's as a sanitary authority, in 1894. Everybody knows Colonel Waring. He afterwards went to Cuba, and he lost his life in seeking to find a remedy for the unsanitary conditions in Havana, where he was sent by the United States government. We also consulted Prof. Dwight Porter. Mr. Storrow has said that we were determined to oppose the project in order to avoid having a row of houses built behind us, and in order that we might continue to empty our private drains into the Charles River; and that for those purposes we employed and paid these gentlemen to find sanitary reasons and reasons in the condition of the harbor to defeat the project. That has been said before you. It was said a year ago in my presence before four committees of the Legislature, before whom this project came, where I had to be silent, because from the very start we had taken the position that we had nothing to say in opposition to the appointment of a committee to investigate the subject. That was the position in which we were put. We consulted those gentlemen, and we said that we wished to pay them for their advice and for the time that they gave to the study of the question. We did not ask for gratuitous service. My own experience leads me to believe that gratuitous service is generally worthless. We did not want that kind of service. We did not want to ask anybody to serve us for nothing, and anybody who is able to render service ought to be paid for it. The laborer is worthy of his hire; and we promised to pay those gentlemen and we did pay them for the advice they gave us and for the study which they gave to the questions involved in the project at our request; and because they did so they have been stigmatized as paid experts, who came before the Harbor and Land Commissioners with opinions on questions of sanitation which had been prepared because we bought them for the purpose of defeating a project which was really opposed by us upon other grounds.

We also, Mr. Chairman and gentlemen, examined the records of the Commonwealth in regard to the question of the effect upon the harbor of Boston of destroying the largest extent of what is called tidal reservoir that is still left to us.

Professor Porter and Colonel Waring advised us that the construction of such a dam as was proposed in this report would be a serious menace to the health of the community where we were living. They advised us that it would raise the level of the ground water, and that was the production of a malarial condition; and you will find that the Joint

Board themselves, in their report on page 10 say that "the conclusion that competent authorities have drawn in all parts of the world is, that the most important condition to be sought for defence against the malarial infection is a thorough drainage of the soil, together with a maintenance of the water contained therein at an unchanged level." Mr. Stearns, the engineer of the Joint Board, afterwards testified before the Harbor and Land Commission that the proposed dam would not raise the level of the ground water, but that it would lower it. If the level of the ground water were lowered, there would be serious danger to our houses, because they are all built on piles, and they are cut off at a level where they are constantly covered with water to prevent rotting. But the weight of authority, and the authority which we chose to trust, was that the level of the ground water would be raised, and that that would produce a condition of affairs that would be threatening to health and probably injurious to health. They advised us it would kill all the shell fish and vegetable life now existing in the basin. There are quantities of clams in the bed of the basin, and there is a good deal of vegetable life now, and they advised us that all this would be destroyed by the conversion of the basin into a fresh-water basin, which would produce very obnoxious conditions; and furthermore, according to the proposal if the water became offensive and obnoxious to let it out after it had been converted into fresh water and to turn it into salt water by an inflow of the tide, that that would destroy all the vegetation of the fresh water, and that the conversion from one to the other would keep up a constant destruction of the vegetable life and shell fish or any other fish in the water in the basin, which would produce very undesirable and offensive and unhealthy conditions. They advised us it would make a very serious difference in the condition of the temperature of the water in the summer. Dr. Barnes has told you. His estimate of six to eight degrees is very moderate. The testimony before the Harbor and Land Commission was that the difference in temperature caused by turning it into a fresh-water basin would be from ten to fifteen degrees. They advised us there was a large amount of sewage which would still continue to flow into the basin. I won't take up your time with the sewage, because Dr. Barnes has dealt with that. He has given you the difference between academic computations made in offices and facts observed by an observer upon the spot. The result was, they said, it would produce unsanitary and malarial conditions, and would probably largely increase the amount

of ice in Boston harbor and destroy the back water, and the assistance of the push, feeble if it is, given by the ebb tide in the river.

In 1869 there was a proposition not to dam the river, but to narrow the channel to 500 feet, and that was opposed by Dr. Oliver Wendell Holmes, Dr. Derby, then the secretary of the Board of Health, and many other distinguished citizens of Boston at a hearing where they testified; and there at that hearing or some other Dr. Derby testified to his own observations of the effect on the temperature of the air in the neighborhood of this basin, — of the cooler water that the basin contains by reason of the tide coming into it. He had observed it from the West End here at one side and all the way around to West Boston bridge, and he testified that on hot summer days there was a difference in temperature of three or four degrees near the basin and in other parts of the city.

With regard to the tidal reservoir question, we examined the records, as I have said. We found that the question of the effect on Boston harbor and the channels of Boston harbor of the destruction of or encroachment upon tidal reservoirs had been examined by successive boards appointed by the city, by the State and by the United States government, beginning in 1835 and from that time down continuously. The first report found was in 1835, where the question was considered by State commissioners, three, at the head of whom was Loammi Baldwin, who was a distinguished engineer at that time. There were further sessions in 1839, 1845, 1846 and 1848; and in 1848 it was reported that the encroachments which had then been made on the tidal reservoir of the harbor of Boston had produced sensible effects upon the currents of the harbor. From 1859 to 1866 a commission of the most competent United States engineers sat here at the request of the city of Boston and made annual reports to the board of aldermen. They were assisted by Professor Mitchell, the extent of whose observations and familiarity with the conditions of the harbor of the city of Boston has never been exceeded by that of any one else; and they were assisted also by Mr. Boschke, whose reputation has survived even to this time as an expert on these questions. In 1866 they made a report to the city of Boston, to the board of aldermen, after the most elaborate investigations. In 1866 upon the suggestion of the United States engineers, the Legislature passed an act providing for the Board of Harbor and Land Commissioners, which was immediately after appointed by the Governor.

Down to that time there had not been a dissenting voice among all the most eminent engineers of every branch of the service in the country, — national, State and city, — there had not been a dissenting voice from the proposition that the encroachment upon the tidal reservoir would be a distinct injury to Boston harbor; and at that time the principle was put into the statute books, and when the Board of Harbor and Land Commissioners was created by statute in 1866 the act contained a provision which has stood there from that time and is in the statute books to-day, in the Revised Laws which were passed by the last Legislature last fall, — the compilation passed by the Legislature last fall, that principle recognizing as an axiom that in every case where encroachment is made upon the tidal reservoir of Boston harbor the Harbor and Land Commissioners shall require compensation to be made by the party making it, which compensation shall consist in dredging an equal amount of area for the tide to flow in to the same extent, or by the payment of money, the maximum amount being thirty-seven and one-half cents, per cubic yard, to be determined by the Harbor and Land Commissioners, to constitute a fund for the purpose of doing the dredging, which otherwise is to be done by the person.

Allow me to remark, in passing, if that principle of compensation should be applied to the destruction of the Back Bay basin, the Charles River basin, by the proposed dam, the amount of money which would be required to be paid for it would be between six and seven millions of dollars.

In 1871 the city constructed Atlantic Avenue, and they were required to provide compensation for the displacement of tide water to the amount of $70,000 and the city of Boston sought to have the law repealed. There was a commission appointed, and there were long hearings before the commission, at which Prof. Henry Mitchell testified, giving his observations of effects upon the harbor which had already resulted from the encroachments made on the area of the tidal reservoir. I am not going to weary you with long statements of all the things we found; but I do want to call your attention to some evidence given before the commission of 1871 by Prof. Benjamin Pierce, then at the head of the Coast Survey, and whose reputation as a man of science and a mathematician stood and stands as high as that of any person in this country. He testified: "I must say, further, that in every case in which there has been a loss of reservoir to Boston harbor it has been a serious injury, and the injury is now going on." Then again he said: "I fear already

that the diminution which has been permitted to be made in the reservoirs up to the present time will be looked back upon with wonder by future generations." Then he said: "It has been said that scientific men have differed in the opinions which they have expressed from time to time." I gave you an instance of that, where the scientific men whom we called said the level of the ground water would be raised, and Mr. Stearns said it would be lowered. Professor Pierce said: "But in one respect they have not differed, and that is, in reference to the tidal reservoirs, that they should be kept undiminished." And from the very beginning of that time in 1835 down to 1894 not one voice of any engineer or any scientific man was raised to call in question that principle which has become embodied in the statutes; and it was left for the engineer of the Joint Board of 1894, — Mr. Stearns, a very accomplished man in his line, but who himself said he did not know very much about harbors, — to doubt it for the first time.

In 1871 the Legislature passed an act which authorized a dam in the South River at Marshfield, with sluiceways and gates; and Prof. Henry L. Whitney at that time prophesied that it would destroy and ruin Green Harbor by shoaling. It has since done so. Also the harbor at Wareham has been greatly impaired by constructions which have been placed in the Narrows, as it is called, where the bridge goes across, and which have caused shoaling, just the connection between the basin and the tidal reservoir above; the connection has been obstructed, and it has been followed by enormous shoaling of the harbor of Wareham below.

From the Navy Yard to Craigie bridge is one of the deepest, most sheltered and best located natural basins of the harbor. We discovered that the outflow velocity of the tide was much greater than the inflow, because it was reinforced by the river current, — the backwater or river current. That was the statement of all those scientific men who examined the harbor, and that was considered a matter of the very greatest importance to preserve for the purpose of carrying material out of the harbor. If it is sound, it is even more important now, with the great amount of sewage discharged at Moon Island and Deer Island. If anything is done which diminishes the force of the current which carries material to the sea from the harbor, that diminution is going to add very greatly to the difficulties and dangers which would result from taking that course of action. The ebb in the Charles River basin lasts six and three-quarter hours; the flood lasts for only five hours.

From 1871 down to the time to which we have come there

have been other reports from other boards, and there have been examinations made of the shoaling in the harbor, and in addition to those, what I have not mentioned before, the reports of our own Board of Harbor and Land Commissioners; and all are unanimous, without a dissenting voice, upon the importance of sustaining this principle of forbidding further encroachment upon the tidal reservoirs.

Well, we got this advice and we discovered this information, and what did we do? Why, at our request, — and I ought perhaps to say on the suggestion of Mr. Stearns himself, because in his report he suggests that the question ought to be examined by the Board of the Commonwealth appointed to deal with these questions, — the Legislature had referred this matter to the Board of Harbor and Land Commissioners. We decided that we should appear before them and oppose the project. We employed counsel. Two of us were lawyers. We had in mind, however, the proverb that a lawyer who advocates his own cause has a fool for his client, and we did not choose to put ourselves in that position; and we employed counsel, — ex-Governor Long and ex-Governor Russell, — who represented us at that hearing. Now, it is not true, gentlemen, that we appeared at that hearing and opposed that project because one element in it was the construction of another row of houses between us and the river. We never gave that a moment's thought. It never struck us as of any particular consequence, for several reasons. We knew it would not be commercially practicable, and, besides that, at the very first hearing before the Harbor and Land Commissioners we were assured, privately assured, by the gentlemen promoting this plan,— and the assurance was repeated, — that that part of the project would not be pressed, but would be abandoned if we would withdraw our opposition. And at all the hearings at which we were represented on that subject nothing whatever was said on that feature of that project. It was also said that we desired to continue to drain into the basin. That also was unjust to us, and is not true. We didn't desire it. We have always been ready to avail ourselves of a sewer if the city of Boston would give us one, and it has never been willing to do it. Dr. Barnes has told you this morning, and I have been told the same thing by Dr. Walcott, that the amount of sewage that goes into the Charles River from the drains of the abutters who have not been provided by the city of Boston with any other means of drainage is infinitesimal, and of no consequence in the consideration of these questions.

Now, Mr. Storrow says, and he tries to convince you,

that the hearing before the Board of Harbor and Land Commissioners was practically *ex parte*. I do not think that was very complimentary to the distinguished counsel who appeared there in behalf of the project. We had there the counsel I have named to you. There were there, supporting the report of the Board of Health, many witnesses, among whom Professor Sedgwick of the Institute of Technology testified. Mr. Stearns was called and testified. Mr. Mattice and Mr. Noyes were called and testified, and two or three other engineers were called and testified, in behalf of the project, beside President Elliot and many other people. There were quite as many witnesses called in support of the project as against it, I think, but I may be wrong about that. Their testimony, I admit, was not so long. For counsel, the project was represented by three very competent and proper gentlemen: they were Mr. Pevey, city solicitor of Cambridge; Mr. Slocum, city solicitor of Newton; and Mr. Abbot, city solicitor of Watertown. They attended all the hearings and cross-examined all our witnesses. When it came to the arguments, the close was given to Mr. Abbot, the city solicitor of Watertown, and he made an argument which was the longest made by anybody before that Board. It occupies 46 pages of the report. The next longest argument was made by Governor Russell, on our side; but, of the arguments which you will find reported in this volume, 68 pages were made by those gentlemen who supported the project of the Joint Board and were in favor of having a dam, while 60 pages are occupied by the arguments of our counsel, who were the only ones that opposed it. Mr. Storrow wants you to believe this was an *ex parte* hearing.

The Board of Harbor and Land Commissioners, — I am not going to say much about that, but I do want to call your attention to one thing. When President Elliot appeared there, he objected to the Board of Harbor and Land Commissioners considering anything but the effect on the harbor, and he seemed to think the introduction of evidence on sanitary grounds was a waste of time, and was going into a subject that was not before them. They, however, concluded to hear it. You will remember in hearing that question and in reporting upon it, they were dealing with a matter which had been considered and reported upon by a co-ordinate Board, with equal authority with themselves under the laws of the Commonwealth. If the subject had been a fresh one, and had not been before the State Board of Health, I think their report would have been more em-

phatic on the sanitary questions. What I want to call your attention to is their statement on page 7: "The greatest possible weight was given to the report of the Joint Board, especially to its conclusions on the sanitary question, whereon the opinions of the State Board of Health are rightfully held to be of the highest authority; and, in so far as this Board may have arrived at any conclusion differing from that report, it has been reached with the greatest reluctance, and, while entertaining the profoundest respect for the judgment with which it differed, it was because this Board was unable to find that the testimony within its reach justified a concurrence of opinions."

Mr. Storrow has told you that that result, that report, was reached because the opponents of the dam had a lot of money, they hired paid experts and distinguished lawyers; while the other side had practically no money, and practically no counsel and no witnesses, and it was practically an *ex parte* hearing. I am willing to admit that, if it is a question of money, we had better retire. We cannot compete in purse with the gentlemen whose names are signed to the petition for this legislation, and who are promoting the inquiry before you.

After this report was made, nothing more was heard of the subject for some years.

One of the Board asked the other day, of Mr. Storrow, I think it was, if he could give him the history of the act of 1898. I can, and I should like to do so. I was part of it. At some time in the latter part of 1897, or early in 1898, Mr. Loring and I were asked to dine with the members of the Metropolitan Park Commission, the Boston Park Commission and the Cambridge Park Commission. When we got to the dinner we were informed that they wished to confer with us upon the subject of a proposed dam. Mr. de las Casas has told you that he had nothing to do with the act of 1898, or with procuring it. Mr. de las Casas was at that dinner, and he told me there that the reason why they wanted to meet us was because a dam was proposed, and the city of Cambridge was anxious to have the question settled if there was to be a dam, in order that they might know where it was to be located, as they wished to go on at once with the improvements on that side of the river. Mr. de las Casas seemed to be interested at the time in the proposition. I don't know that he signed the petition for the act, but he was there, and he knew what was going on, and he did the talking to us. They said they wanted to have the dam at Cottage Farm station, and they wished to know whether we would oppose

it. We told them we could not answer that question without consulting our advisers. Thereupon there was an informal agreement — I didn't want to do it, I objected to it — but there was an informal agreement that I should be on a committee with the chairmen of these three Boards, — Mr. de las Casas of the Metropolitan Park Board, Mr. Stratton of the Boston Park Commission and Mr. Cox of the Cambridge Park Commission, and also Dr. Walcott. We had one or two meetings at Dr. Walcott's office. I consulted again Colonel Waring and Professor Porter, and we paid them for their advice; and they advised us that a dam at Cottage Farm, at St. Mary's Street, would not produce unsanitary conditions below, and would do us no harm, no matter what might be the effect of it above. I thereupon met these gentlemen, and told them the people of Beacon Street would not oppose legislation authorizing the construction of a dam at St. Mary's Street. They said that was not enough, that they wanted us to assist them, that they wanted us to go before a committee of the Legislature; and if they got the dam, they wanted us to go to Washington and help get the consent of the United States authorities. We said we would take no part whatever; all we would do would be to stand aside and let them do what they could. That we did, and no more. We simply said we did not oppose it, would not oppose it, because it did not concern us so far as the sanitary conditions were concerned, on the advice of our sanitary experts, — and we paid them again for their advice.

The first thing to be done under the act of 1898 was the preparation of plans to be submitted by the Metropolitan Park Commissioners to the Board of Harbor and Land Commissioners. Those plans were never prepared. Mr. de las Casas said here the reason they were not prepared, as I understood him, was because there was no provision in the act for paying expenses, and because the Board hoped that, if no dam were constructed there, there might be an opportunity to construct one at a point which they regarded as better for the æsthetic conditions of the river. That was not what he told me in 1899, after the act was passed. Six months or a year afterward — I didn't take much interest in the project of the dam — but I happened to see him, and I asked him whether those plans had been submitted to the Board of Harbor and Land Commissioners. He told me no, and that the reason was that the Metropolitan Park Board had been so occupied with completing their takings that they had not had time to attend to it. That was the reason he gave me then, and the only reason. He said

nothing about a dam anywhere else, or about the expense. About the expense he is mistaken, for in the second section of the act full provision is made for the issuance of scrip for payment of all expense connected therewith.

In the mean time, gentlemen, we have been exerting ourselves and making an effort to get an esplanade built along the shore of the river behind our houses. We had plans prepared for us, we went to the Boston Park Commission and asked them to take it up and build it for us, offering to pay half the expense. We called the subject to the attention of the Metropolitan Park Commissioners. We didn't ask them to do it, but they asked to see our plans, and I had them sent to their office and they expressed great pleasure and admiration of them; nobody condemned them. Mr. de las Casas said the other day they didn't amount to anything, and that one of them provided an esplanade with paving. There was no such feature in those plans. I went to their rooms when the plans were there, and they all expressed great admiration of the plans; and one of them, Mr. Haskell, said he hoped to see that esplanade built. But we were not allowed to build it, and when we went to the Legislature on two occasions to ask for an act to have that esplanade built and have us ordered to pay half the expenses of building it, we were defeated; and the opposition came from the gentlemen who were in favor of the construction of a dam at Craigie bridge; and the principal witness called against us was the engineer of the Metropolitan Park Commission, I think he was, — Mr. Eliot, at any rate; and he said it would cost money, and that it was an affair of the future, and there were other things that were more immediately desirable, and that that project could afford to wait sixteen or eighteen years. That was after they had printed and published this report in 1894, containing pictures of the back side of Beacon Street, for the purpose of bringing us into disrepute because of the condition of affairs there; and when we wanted to remedy it, they said it was a matter of years. I asked at that hearing if he put that picture in there, and what he did it for. I didn't get any answer.

Now I come to the more immediate action, the position that we have taken on the proposition since it was broached again about a year ago. I want to say that whatever public sentiment exists to-day on this subject is the result, in my opinion, to a large extent, of misapprehension. It is not generally understood that what is proposed now is to convert this basin into a fresh-water mill pond, with a sluggish

stream flowing into one end of it. Did I say a fresh-water mill pond? I take it back, — a pond full of diluted sewage, with a sluggish stream flowing into one end of it. The understanding of the community, as I shall show you by the papers, is that we are to have a basin into which the tide shall flow at least once in twenty-four hours. I attended the hearings last year, as I have stated. It was there stated in behalf of this project every time, that a new plan had been discovered which would obviate all the objections that were raised in 1894; that there was to be a collapsible dam which should be lowered at least once in every twenty-four hours; that in the day time it would be desirable to keep the basin full, so that persons might row and boat and swim in it, but during the dark hours, when nobody would see it, and see the hideousness of what was exposed, then the dam would be collapsed, and the tide would be allowed to flow in and flow out just as it does now.

On the 14th of January, 1901, we addressed to our neighbors this communication: —

It has come to our knowledge that signatures have lately been requested to a petition to the Legislature for authority to construct a dam in the Charles River at or near Craigie bridge, thus preventing the ebb and flow of the tide in the Back Bay, and turning it into substantially a fresh-water pond.

This is the same project which was proposed in the report of the Joint Board upon the improvement of Charles River in 1894, and furnished the occasion for the appointment of your committee at that time to oppose it. It was proposed then, as part of it, to fill the flats in the rear of our houses, and build a row of houses between us and the river. But little notice, however, was then taken of this part of the project, and whether it is again proposed at the present time your committee is not informed.

The main ground upon which we opposed it before the Board of Harbor and Land Commissioners, to whom the matter was referred by the Legislature of 1894, was because it would greatly endanger the health of the residents of the north side of Beacon Street, and also because of the probable injury which such a dam would cause to Boston harbor. The late Col. George E. Waring, Jr., Prof. Dwight Porter of the Massachusetts Institute of Technology, and other distinguished experts, testified before the Board that the erection of such a dam would cause malarial conditions, and would be a source of serious danger to health.

We earnestly warn you against signing any petition in support of this project, and advise you, if you have already inadvertently signed such petition, to withdraw your signature by a letter to this committee.

L. S. Dabney,
Charles Head,
H. Stockton,
Committee.

Boston, Jan. 14, 1901.

The petition was presented at the State House. It was accompanied by an act authorizing the Metropolitan Park Commissioners to construct a dam in the immediate vicinity of Craigie bridge. When that petition got into the Legislature it was referred to the committee on rules, because there is a statute of the Commonwealth which requires petitions for legislation affecting tide water to be publicly advertised by notice to be printed three or four weeks before the beginning of the session, and this petition had not been advertised; and when these gentlemen got before the committee they found they were likely to have their petition thrown out, for the reason that it had not been advertised; and they then changed it into a petition for the appointment of a committee to investigate the subject. I was there, and the Speaker of the House asked me whether the people of Beacon Street would oppose the appointment of a committee to investigate the subject. I told him certainly not; that we should make no opposition to it whatever; and I so told my friend, who was there at the time [turning to Mr. Matthews], and we made none from the beginning to the end.

But the next thing that they did was to address a circular, accompanied by a pamphlet, to the residents of the north side of Beacon Street, as follows: —

You were doubtless somewhat alarmed by the receipt of a circular, dated Jan. 14, 1901, and signed by Messrs. Dabney, Head and Stockton, stating that your signatures were to be asked for a petition to the Legislature, to carry out "*the same project*" —

those three words — "*the same project*" — in italics and in quotation marks in the circular.

— in relation to the construction of a dam in the Charles River that "was proposed in 1894."

The undersigned wish to inform you that there is no movement on foot to carry out "the same project" that was proposed in 1894, or to turn the Back Bay basin "into substantially a fresh-water pond," but that the present project is radically different in almost every important particular from that of 1894.

The signers of the circular of January 14 tell you that they "are not informed" as to whether it is part of the plan of the undersigned to "fill in the flats in the rear of [your] houses, to build a row of houses between [you] and the river." On this point the undersigned beg to state that they are now and always have been opposed to any such filling in of the basin.

The plans of the undersigned, if carried out, would involve but a slight expense to you as owners of residences on the north side of Beacon Street, but would add greatly to the value and attractiveness of your properties. The investigation of this new project by a competent commission, appointed by the Governor or the Legislature, which is all

the undersigned now ask, will not involve the slightest expense to the residents of the north side of Beacon Street.

As this is entirely a project for the public welfare, and one in which the undersigned are seeking no private gain whatsoever, it is hoped that, before taking any stand in opposition to such investigation, and especially before contributing to any fund to oppose the appointment of a commission, you will read the accompanying illustrated pamphlet, which exactly explains the position of the undersigned on all questions raised by the proposed improvement of the Back Bay basin.

Now, those people down there believe to-day that what is proposed is a half-tide or collapsible dam. That circular was written and sent to our neighbors after we had publicly, before the committee of the Legislature, assured these gentlemen, and assured them privately also, that no opposition would be made to the appointment of a committee. They then addressed a circular to our neighbors asking them not to oppose the appointment of a committee and not to contribute any money for that purpose. That circular was accompanied by a pamphlet. I want to call attention to a statement on pages 5 and 6 of that pamphlet. This is what was said to us, and what we were told was proposed: —

Assuming, for the sake of argument, that there is any effective scour left to the comparatively weak currents now engendered in the harbor (and we have competent authority for believing there is none), we desire to have the proposed commission report what sum will make good, by dredging, such filling in as may be caused by putting a half-tide or some form of collapsible dam at the West Boston or Craigie bridge.

Now, those people down there believe to-day that what is proposed is a half-tide or collapsible dam at the West Boston or Craigie bridge, which will leave this basin salt water. Very few of them have any idea it is proposed to turn it into a fresh-water basin; and they believe so on the faith of the representations that were made a year ago by circulars addressed to them by the gentlemen who are now promoting this scheme.

The year before this, in 1899, after the act of 1898 was passed, the boys at Cambridge waked up to the knowledge that there was an act passed for the creation of a dam at Cottage Farm, and they thought that would injure the river for the purposes of their rowing, which no doubt it would. They put in a petition to the Legislature to repeal it; but they found themselves in this position, that the repeal of it would be opposed by the Metropolitan Park Commission, unless another dam was given to them somewhere else. Then they put in another petition, or somebody else did, for the construction of a dam at Craigie bridge. That was

not advertised, and the committee on rules threw it out. When the petition for the repeal of the act of '98 came before the committee on metropolitan affairs, I was there. They appeared and asked to have it referred to the next General Court, and it was referred to the next General Court, because, without a substitute offered they were afraid they would not be able, against the opposition of the Metropolitan Park Commission, to repeal that act.

When we came to see the petition that was presented the next year, out of which the appointment of this commission grew, and read the names signed to it, it was very significant to us of the source from which it came. The first name on the petition was that of Mr. Henry L. Higginson, who is the benefactor of Harvard in all athletic and other matters. The next was Augustus Hemenway, who has given the boys a gymnasium at Harvard. The next name is that of George W. Weld, who has given them a boathouse. The next name is that of James J. Storrow, who was the stroke oar of the University crew when in college, and has been its head coach since. Those are the names which headed the petition in 1901 out of which the act grew under which this committee was appointed.

Mr. Youngman. One correction, if you will permit me.

Mr. Dabney. Certainly; I wish to be corrected if I make any mistakes.

Mr. Youngman. The petition presented to the Legislature was not presented by the college boys or by the college clubs; in fact, they had no participation in it. It was presented by the rowing associations of Boston and New England.

Mr. Dabney. Well, I don't suppose they opposed it, did they?

Mr. Youngman. No, the college boys did not oppose it; but those clubs came from all over New England, and particularly right around here.

Mr. Dabney. Now, in turning over my papers I find this on the subject I was last speaking of, about the expectation of the community in regard to what is projected, — a letter from Mr. Rhodes, the historian, from Seal Harbor, Me.: "I am in favor of the dam, provided salt water is allowed to flow into the basin at least once in twenty-four hours."

It is not anticipated that the 540,000,000 cubic feet of water that now, twice every day, flows into this basin from the cooler waters of the harbor is going to be entirely excluded when it is required to renew the water of this basin on account of excessive pollution,— an act which Dr. Barnes

has told you is liable to be required, in excessively hot weather, every day.

We are pointed — we were in 1894 and are now — to the Alster basin at Hamburg. The Alster basin at Hamburg is a basin created out of a branch that flows into the Elbe, — fresh water. It is 70 miles from the sea. The temperature of the water in summer is very much cooler than it is in the Charles River above the dam at Watertown. We were not told then, and you have not been told now, what is a fact, — that no sewage whatever is permitted to get into the Alster basin; every particle of sewage is rigorously excluded, and not only that, but even the surface water of the streets is excluded from it and not allowed to go into it at all. Nothing is allowed to go into it. The State Board of Health in 1894 said something about the Alster basin in connection with the cholera in Hamburg in '92. The Alster basin had no more to do with the cholera than the Farmers' Almanac had to do with it. I have seen an authentic map of the city of Hamburg, with a line running through the city of Hamburg from one side to the other, and that map is covered with black-headed pins, showing the location of the cholera districts in 1892. On one side of the line the black pins are so close that there is hardly room to put in another; on the other side of the line the map is almost entirely white, and there is scarcely a pin there. The water used in the city is taken throughout from the river; and the fact is, that on the side of the map where the black pins are it is used without filtering, while on the other side it is filtered.

This dam is an experiment. Our position is that at best it is a dangerous experiment.

Oh, there is another paper I ought to read to you, because it states precisely our position. After that communication accompanied by the pamphlet, we sent this one: —

We suppose that you have all received a pamphlet entitled "The improvement of the Charles River basin," and enclosed with it a printed communication, bearing the names of Mr. Henry L. Higginson and others, addressed "To the residents of the north side of Beacon Street." Both contain many errors and misstatements.

The petition to which these gentlemen were seeking to obtain signatures, when our circular of Jan. 14, 1901, was addressed to you, was not a petition for the investigation of a new project by a competent commission appointed by the Governor or the Legislature, which they say is all they now ask, but was, as appears by the bill introduced with it, a petition to the Legislature for authority to the Board of Metropolitan Park Commissioners, simply, without any investigation, to construct and maintain a dam with a suitable lock or locks across the Charles River from Leverett Street extended in Boston to a point nearly opposite in Cambridge, without further description of the proposed dam, or

information as to its character or management, so that, for all that appeared, it was exactly the project proposed in 1894.

When this petition was presented to the Legislature it was referred to the committee on rules; and when the petitioners found that it was likely to be thrown out for lack of prior advertising required by the rules, they withdrew it at a hearing before that committee, and substituted for it their present petition for the appointment of a commission to investigate the subject. Thereupon your committee at once publicly stated, in the presence of many of the gentlemen whose names are attached to the above-mentioned printed communication, that we should make no opposition to the appointment of a proper commission, and private assurances to the same effect have been since repeated to them. They nevertheless see fit to request you to read their pamphlet "before contributing to any fund to oppose the appointment of a commission." We have asked for no contribution to any fund for that purpose. There is danger that any of you who send your names to Mr. Higginson, as requested, will be considered and represented to favor, not merely the appointment of a commission to investigate, but the construction of a dam as proposed.

In 1894 some of the most competent and accomplished experts on the subject that could be found testified that the construction and maintenance of a dam between Boston and Cambridge at Craigie bridge would produce conditions in the Back Bay that would be a serious menace to health, and gave their reasons for their views at length. The pamphlet of Mr. Higginson and others fails to answer their reasons. These gentlemen are stigmatized in the pamphlet as "paid experts." They were paid, of course, for their time and services in investigating and studying the conditions and in attending the hearings; but do Mr. Henry L. Higginson and the other gentlemen whose names are appended to the pamphlet mean to imply that the opinions and testimony of the late Col. George E. Waring, Jr., of Dr. Henry J. Barnes, of Prof. Dwight Porter and of others were bought or influenced by the payment of money? It is still to-day the opinion of competent and accomplished persons, thoroughly familiar with the subject that the construction of a dam as proposed would create conditions that are a serious menace to health. It is no doubt known to many of you that malaria prevails to an alarming extent along the banks of the Charles River above tide water, and also along the banks of the Neponset.

It was not disputed by experts in 1894 that disturbance of the level of the ground water, especially by raising it, is a cause of malarial conditions, and one concerning which as a cause there is least doubt. It is the opinion of well-informed hydraulic engineers that the level of the ground water will inevitably be raised if the tide is allowed to flow out of the basin once only in twenty-four hours, even if during the rest of the time the level of the water in the basin is kept at an average height of a little over 7 feet.

Your committee believe that, if it be the opinion of skilled and competent persons, familiar with the conditions, that the construction of the proposed dam would be dangerous to your health, they should in your behalf oppose it, although equally skilled and competent persons, familiar with the conditions, should be of the contrary opinion; because the thing must be in that case an experiment, and the interests are too great and the matter too serious to be made the subject of experiment. We believe that it should be opposed unless it be clearly shown that it can be done without danger to health, and cannot be fairly said to be an experiment, without reasonable certainty as to the result, until the result shall appear.

We do not propose to make any opposition to the appointment of a proper commission to investigate the matter. We do propose, as your committee and in your behalf, if a commission shall be appointed to investigate the subject of the proposed dam, to see to it, so far as we can, that it shall be composed of competent and impartial persons, and shall be required to hear persons interested; and we propose also to take part in the hearings before such commission.

It is important to us to know whom we can properly say we represent as a committee in this matter, and we therefore request you to indicate that we are or are not acting with your approval, in your behalf, by returning the enclosed card with the word "Yes" or "No" written over your signature.

To that communication we received 87 replies, 76 of which were "Yes" — we were acting with the approval of the people residing on Beacon Street — and 11 were "No."

We said in that, and I repeat, that this is an experiment; and Mr. Matthews confesses it to be an experiment, when he devises and introduces in his plan for a dam those tidal sluiceways against the advice of his engineer.

Mr. Matthews. Not against their advice.

Mr. Dabney. Well, without the advice of his engineers; and he confesses it in what he says with regard to the advisability of putting those sluiceways into the dam. I say it is a confession that it is an experiment; and it is an experiment, and I say it is a matter in which no experiment should be tried. We do know now that the health of the district is good, notwithstanding the enormous amount of sewage poured into the river. I agree that none should be poured into it, — I am with them so far. But we do know now that the health of the district is good. There is no malaria there. They say there is no malaria on the banks of the Charles anywhere. I am skeptical about that. I showed to Mr. Dana a month ago a report of cases of malaria found at Harvard College last year; I think there were 46. But at any rate there has been a great deal of malaria found on the Charles River above the Watertown dam, and there has been malaria along the banks of the Neponset, where the water is fresh. They tell us that modern science, since the investigation of 1894, has discovered that malaria is caused by a mosquito with a name which Mr. Storrow said was Latin, but which I supposed was Greek. I think it is the *genus Anopheles*. I supposed it was Greek. But whether it be Greek or Latin, there has been, everybody will admit, a very vigorous translation of him at work on the Charles River above the Watertown dam and also on the Neponset River. If it be true that he is essential for the conveyance of the poison, it must be equally true that something else

has got to be responsible, or there has got to be some place provided where he can find that poison to convey. Now, I don't believe there are any conditions existing which will prevent the migration of this translation of the Greek mosquito into the neighborhood of the Back Bay if there should be an opportunity for him there; and if conditions exist which provide him with the poison, I believe that there are no reasons why he should not pursue his wicked work there just as well as anywhere else.

What is the purpose? I don't understand that there is any purpose in this scheme except the æsthetic purpose, because it is supposed that it will improve the looks of the river and beautify the city of Boston. On those subjects opinions are very apt to differ. Some people don't think it will. Some people think that, if the banks of the river are improved, if we could have our esplanade along the north side of Beacon Street, and similar improvements could be made along the other side, the present condition of affairs is quite as æsthetic as any which would be produced by converting this basin into a basin of diluted sewage, with some grass along the bank. But however that may be, every purpose, it seems to me, — every æsthetic purpose that is sought could be equally well reached by dredging the river to a depth of 5 feet from the Watertown dam down, so that always the bed of the river should be covered at low tide. It is admitted in the report of the Joint Board that if the river be dammed it is necessary that the present deposits of objectionable sewage which are now found in the bed of the stream should be removed, particularly down here in the Back Bay. They have got to be dredged out, anyway. It seems to me, speaking for myself alone,— and there are not a few who agree with me to my certain knowledge, but I don't know generally what the views of the people on the north side of Beacon Street are, — but it seems to me, if the river were dredged from the Watertown dam so that there would be always 5 feet of water in it, you would have everything which it is necessary to have for the purpose of turning this stream to the best advantage to which it could be turned for the purposes of beauty and the adornment of the city; and yet you would not be making an experiment which would change radically the conditions and the character of the water and the inflow and outflow of the tide, which is now sufficient to carry away all the sewage which is emptied into this basin, so as to prevent pollution and to do no harm.

If it is necessary to have a dam in order to satisfy the

aspirations for beauty, and if they would not be sufficiently satisfied by dredging the river, as I have said, why not give us a half-dam? I do not know whether the objections to that will be so great from the harbor point of view. I never asked anybody on that, and I am not an expert on the subject, don't know anything about it; I don't know whether it would or not. So far as sanitary objections are concerned, it seems to me that a half-dam, say at grade 5, which would admit of a bi-daily — twice-a-day — flow of all the tide above grade 5, would be free from many of the objections (objections which seem to me insuperable) that exist to the proposed dam, which shall make the water fresh and keep it at an elevation of grade 8. They say that the sewage will be diluted. Well, they can't furnish us with a Titan with a big spoon to stir it up and see that it is diluted. It will not dilute itself. With that sluggish stream flowing into it at the upper end, there will be plenty of places where, as Dr. Barnes has said, there would be no current at all, and where sewage would be very likely to exist. He says until you try the experiment you won't know where the current will be. I think it would be quite as likely that it would be over on the Cambridge side, or in the middle of the river. Take that map there which shows the sewers that empty into the basin from the Boston side, on the north side of Beacon Street, — street sewers, I don't mean small house sewers, but street sewers. They are going to be emptying into water which is practically stagnant. It is not going to be stirred up, and there is going to be an immense amount of pollution there. Whether that will be sufficient, whether that will be pollution the evil effects of which can be obviated by letting in water through a sluice once a day or once a week, is an experiment which cannot be answered with certainty until the experiment has been tried. If you put a half-dam, say at grade 5, and let the tide come in as it now comes in, we shall still have a salt-water basin, we shall still have a cool basin comparatively, we shall still have an amount of water coming in there every day fresh to dilute that sewage, which will be excluded if the dam is made tight, if the basin is converted into a fresh-water basin, and if no free flow of the water is permitted twice every day, as it ought to be.

I thank you, gentlemen, for your attention. I think I have said everything I want to say.

Mr. Matthews. May I ask you one question? Don't you understand the dam we propose this year with tidal sluices can be operated so as to make a half-tide dam, as

you call it, — that is to say, so that the basin behind it shall be made a half-tidal basin, in the manner you propose?

Mr. DABNEY. I don't know whether I do understand that or not. I have no doubt you can construct such a dam. I don't see any object in constructing a high dam and having it work so that the result, the effect, would be just as it is in a half-dam. But I do understand the purpose of your dam is to turn this basin into a fresh-water basin instead of a salt-water basin, and that is what we very greatly object to.

Mr. MATTHEWS. Our purpose is to turn it into a fresh-water basin if that is found to be not objectionable in operation. If it is found to be objectionable in operation, we understand Mr. Blake to say this dam could be operated for half-tide purposes.

Mr. DABNEY. I object to turning it into a fresh-water basin. I want the tide to come in there every day, and I want the salt water.

Mr. MATTHEWS. The only question I wanted to put to you was, whether you understood that Mr. Blake's or Mr. Shedd's tidal sluices, from any person that you have consulted, could not be used to make a half-tide basin.

Mr. DABNEY. Could not be? Oh, no, I haven't consulted with any one.

Mr. MATTHEWS. You would simply suggest that as a point for the committee to take into account and consider, as far as the type of structure is concerned.

Mr. DABNEY. If it could not be, I think it is fatal —

Mr. MATTHEWS. On your theory.

Mr. DABNEY. No, on yours.

Mr. MATTHEWS. I don't yet understand your position about it.

Mr. DABNEY. I am sorry if I am so obscure.

Mr. MATTHEWS. You said to the committee your objection to our proposition was that we did not propose any half-tide dam.

Mr. DABNEY. No.

Mr. MATTHEWS. I thought we did propose a type of structure which could be used to make a half-tide dam, if that were found to be the best way to operate the basin in practice.

Mr. DABNEY. I didn't say I objected because you do not propose a half-tide dam. I said if we have got to have a dam that a half-tide dam would be less objectionable than the one you propose, and that not as a question of structure altogether, but as a question of operation; because you tell

us that you want to turn that basin into a mill pond with a sluggish stream flowing into one end of it, exclude the salt water if it is possible to do it, and never let it get above grade 8 if you can possibly do so, — and that is what you tell us, and what we object to.

Mr. MATTHEWS. You did not mean to tell the committee that Mr. Blake's or Mr. Shedd's tidal sluices were not sufficiently large to operate the basin as a half-tidal basin?

Mr. DABNEY. I did not mean to have the committee understand that, and the committee would not understand that I pretended to have any knowledge myself on the matter.

Mr. MATTHEWS. Now, don't you think you ought to acquit me of writing this pamphlet?

Mr. DABNEY. I didn't say you wrote it; I said it came with the circular which bears your name. I am glad you are ashamed of it.

Mr. MATTHEWS. I am not ashamed of it. My Brother Dabney, with his usual ingenuity, has twisted some of the sentences.

Mr. DABNEY. I wish you would read the sentences I twisted.

Mr. MATTHEWS. I would like to read the whole of it. This is pages 5 and 6: "Assuming, for the sake of argument that there is" —

Mr. DABNEY. That is what I read; that is where I began.

Mr. MATTHEWS. "Assuming, for the sake of argument, that there is any effective scour left to the comparatively weak currents now engendered in the harbor (and we have competent authority for believing there is none), we desire to have the proposed commission report what sum will make good, by dredging, such filling in as may be caused by putting a half-tide or some form of collapsible dam at the West Boston or Craigie bridge." Now, that is the only reference I can find to a half-tide or collapsible dam in the whole pamphlet.

Mr. DABNEY. How many times do you want to say it? When we are told a thing on Beacon Street once, we have capacity enough to understand it.

Mr. MATTHEWS. We don't propose that as the only alternative.

Mr. DUNBAR. I think you do.

Mr. DABNEY. Here is another pamphlet on the improvement of Charles River basin which does have Mr. Matthews' name printed in it, and a picture of a collapsible dam in the Ohio River.

Mr. MATTHEWS. Yes, undoubtedly; but not as a conclusion.

Mr. DABNEY. Didn't you mean to have us understand, when you were making those statements, that this was your proposition?

Mr. MATTHEWS. No. I would like to take up that statement. Mr. Dabney states that he [Mr. Storrow] represented that it was to be a collapsible dam, and that those who now support this proposition or who supported this proposition represented that it was to be a collapsible dam.

Mr. DABNEY. I didn't say those in support of the proposition.

Mr. MATTHEWS. Those who supported the proposition before the Legislature of last year.

Mr. DABNEY. No, I said you represented to our people on Beacon Street —

Mr. MATTHEWS. Your people?

Mr. DABNEY — to induce them to withdraw their opposition, that you told them that you were going to have a salt-water basin and a collapsible dam.

Mr. MATTHEWS. That was just what we said, wasn't it, what you have just read. Isn't it?

Mr. DABNEY. Yes.

Mr. MATTHEWS. Now, I would like the committee to take both those pamphlets. There is no conceivable inference to be drawn from those two documents, or either of them, that we proposed to have a collapsible dam or a half-tide dam. We did point out, however, in both of these pamphlets and also in the argument which I made before the legislative committee, that those two systems of construction had become known to engineering science since the investigation of '94; and we referred to the bear trap dams in the Ohio River and to the Richmond lock dam in the Thames River, built since that report. We said those were possibilities of the situation that ought to be taken into account; and if there was any conceivable objection, such as has been stated, to a fresh-water basin, why, a dam of this form, or either form, would obviate that objection. But we never attempted to secure any help of this project by pinning ourselves down to a half-tide dam, or a basin which should be operated as a salt-water basin, which we don't believe this basin ever will be; but we do think a dam should be so constructed that salt water can be let in when necessary.

Mr. DABNEY. I want to repeat, — no, not to repeat, but I want to say that I was present at those committee meetings, I heard the statements made by Mr. Storrow and Mr.

Matthews, I read their pamphlets, and it never occurred to me that they were seeking or had any plan but for a collapsible dam, as they set it forth in their pamphlets; and that is the impression I have got, and that is the idea other people have got.

Mr. MATTHEWS. We hadn't any plan at the time, and told the committee so. We have now. Now, there has been a good deal of talk at these hearings as to what the city of Boston is going to do about its main drainage system in Dorchester.

Commissioner DANA. The half-dam you are thinking of, Mr. Dabney, in order to prevent backing up when a rain storm occurs at high tide, would have to be also a dam which would prevent the water rising above a certain level, say 10 or 11 grade, wouldn't it?

Mr. DABNEY. No, I don't understand so. I understand the water would flow freely over it when it reached grade 5; that it would both come in and go out.

Commissioner DANA. Then there would be nothing to prevent the backing up, the overflowing into cellars in the Back Bay district, where the people are on the combined system, which now occurs?

Mr. DABNEY. You mean the effect of the high water would be just the same as it is now?

Commissioner DANA. Yes.

Mr. DABNEY. I suppose it would. I don't object to that.

Commissioner DANA. You are not on the combined system in your house.

Mr. DABNEY. Well I am perfectly willing to be put on the combined, and then I don't object to the water if it comes in. The water don't come in out of the sewers there, it comes in over the top of the wall when it comes in anywhere.

Mr. DE LAS CASAS. Mr. Dabney, may I offer a word of explanation? I would like to say the only point he has quoted on which I could agree absolutely with him is that I made an error in referring to a plan with a paved surface having been presented by his committee. I think I was in error in saying that. And further, as to all the plans, if there is any difference between us, his recollection of the plans which they presented is undoubtedly very much more correct than mine, as they were prepared by him or through his agency; and anything that I may have said in regard to that I should wish to have withdrawn, — the plans, I mean, which were prepared subsequent to the report of the Joint Board. Whether Mr. Dabney allowed us to see them be-

cause we asked to see them, or whether Mr. Dabney asked us to look at them, I don't know. I do recollect the one result, that we suggested it was not for us to consider those, but for the Boston Park Commission, and that we did not discuss the question of whether we approved or disapproved them, as said. We did treat them —

Mr. Dabney. But you didn't treat them with scorn.

Mr. de las Casas. Oh, no; they were very beautiful plans, prepared by eminent architects.

The Chairman. The committee, at its various hearings and in advance of the hearings, has advertised the fact that it was glad to listen to any person interested in this matter and who had anything to present either on one side or on the other. The attitude of this committee has always been to give the fullest possible opportunity to all parties to present their views. In response to that invitation, a number of gentlemen have appeared on one side and on the other and made statements. In most cases those statements have been presented in writing, and in the opinion of the committee that is the best way of presenting evidence, because the committee can then consider these statements, and our expert and ourselves can go over it. The committee having advertised these hearings and having consulted with those interested on the one side or the other, gave notice that this would be the last public hearing, inasmuch as those who had wished to be heard had either done so or had handed in statements. The committee, however, is most desirous to hear any one who may have anything to present which is germane to the subject, and it extends the invitation again, and, if necessary, would again hold public hearings to give interested parties an opportunity to be heard. The committee would be glad to know whether any one here desires to be heard.

Statement by Mr. Gamaliel Bradford.

Mr. Chairman and gentlemen, this is a matter for generations to come, — it is not for the present alone; and with your permission I will submit what remarks I have to make. It is one of the peculiarities of our admirable State government that no question seems ever to be settled. When our Legislature meets at the beginning of the year matters are poured into it by the score, yes, even by the hundred; and it can well be said that every private or public interest will find schemes for change proposed during the session of the Legislature. The consequence is that no interest, no de-

partment of government or anything whatever has the slightest protection against attack at any time. If we may use the expressions of military language, we may say that the science of attack has far outrun the science of defence. Therefore I say there is one omission they have made in that large new State House. They ought to have put over it, "Eternal vigilance is the price of liberty." In 1894 this subject was brought up and gone all through with from beginning to end, at great expense of time and labor, and the result was this large volume of printed evidence and argument. The Harbor and Land Commission said no to the proposition. Now, you would have supposed that that careful investigation and that decision might have lasted for at least a generation; but not at all. Within seven years we are called upon to go all through this matter again, to give our time and trouble in the other case for nothing, and to go all over the subject again.

The arguments in behalf of this enterprise may be divided into three. One is positive and the others are negative. One is that it will increase the beauty and attractiveness of the river, the second is that it will not injure the health of the city, and the third that it will not injure the harbor.

Now, when I hear anybody speak of increasing the beauty and attractiveness of the river, I come to one of three conclusions, — either that their sense of beauty is lamentably defective, or that they have not had adequate opportunities to judge, or that they are using that motive to cover up some other, — that that argument which they put forward is not the real one. I have lived for seventy years around this region. From the time I was two until I was eight I lived at the Massachusetts General Hospital, within one hundred rods of the water. After that for some years I lived in Cambridge, and was constantly walking back and forth over the bridge. We had nothing then practically but omnibuses, and I was far too poor to ride in them. The last year I was in college I lived in Boston and walked out and back every day over that bridge, at least five hundred times in that year. I lived that year on Charles Street, where I could see across the whole basin. Afterwards I was a clerk in business and in business myself, and it was my regular practice for some years, four times a week, to walk out over the mill dam to Cambridgeport and back in town that way. For the last thirteen years I have lived in a building that looks down on the river, and enjoyed its full beauty. Those who live along the banks of the river know quite well what that beauty is. One of the petitioners

lives on Commonwealth Avenue; one lives on the south side of Beacon Street, where he cannot see the river; and one lives in Brookline; and they are all, I presume, away all summer long. When it comes to personal testimony and opinion, my testimony can stand against theirs.

Now, that river under present conditions is rarely frozen up in winter time; but if the scheme proposed of placing a dam there is allowed to go through, you will have the river frozen up at Thanksgiving, and it will stay frozen until March or April; and, with all the smoke of the houses and factories along there, you will have one great dirty field of ice the whole length of the river. As I say, at the present time it is rarely frozen up. Last January the Charles River was as blue and bright as it was in June. Then, again, during the winter time the river is full of ducks and gulls. Those beautiful creatures just swarm along the banks of the river, and many a city pays thousands of dollars for such, in the way of aquariums and ponds. Those gulls and black and white ducks fly back and forth on the river and lend it a great charm to thousands and thousands of people who enjoy that sort of thing. They will all be banished, you will never have one of them again, if you place a dam across the river.

Take the effect on the tide. I remember some years ago there was an exhibition at the St. Botolph Club of pictures by Monet, marine views and such, and one could scarcely believe that such views could be seen in real life along rivers anywhere; but a day or two after, as I looked out from the windows of my house upon the Charles, there was all the beauty that I had seen in those pictures, only it was far more beautiful. When the tide is coming in with the wind against it, the river positively dances, and thrills one's heart with joy to see it flashing in the sunlight; and yet those people, with their proposed dam, want to change all of that life and beauty into a dead level pond all the time. The waters of a pond have no life to them. Go out to Jamaica Pond, beautiful as sheets of water always are, but the water is one calm, dead level, without any life. Go out west, and upon those great lakes, those large sheets of beautiful water, and note the absence of the rush of the tide; there is no motion, no life to them at all. Take it down on the north shore, where Mr. Higginson lives, and how is it there? They go there because of the beautiful scenery; but it is the flow and the rush and the dancing of the tide that give to the waters of the north shore their greatest beauty. So it is with the Charles River. There

is no doubt that when the tide is out the river is not beautiful, but that only lasts for about three hours in the twenty-four, and half of that is in the night time. So I say that the movement to place a dam across the river and to prevent the motion of the tide back and forth is going to destroy the beauty of the river, and I think it will be a great injury to the city of Boston. We are told of the beauty of the Alster at Hamburg and of the Richmond dam at the Thames, but it is not shown that the conditions are the same. One gentleman has just stated that the Thames dam is about where Riverside would be to Boston. Another says that no sewage whatever is allowed to flow into the Alster basin. Well, it is some twenty years since I was in Hamburg, but if I remember correctly, the Alster basin is made beautiful by fine houses and wide streets and stone piers facing on the basin. You cannot have them in the Back Bay. The selfish dwellers on the Back Bay furnished a great leverage in the past, but, as Mr. Dabney has said, they consented to have an esplanade built out for thirty feet, but the others are determined to have a dam placed across below, and have resisted the project for an esplanade.

Now, I want to compress this statement as much as possible, and I will come to the sanitary question. In the seventy years I have lived near the river I have never heard any complaint of the prevalence of malaria or any other trouble coming from that river. That is a crucial test. Four or five years ago they dredged out the river and spread out all of the material along the shore on the Cambridge side, right in the sun, and if any cause would produce malaria, it seems as if that would; but it did not, and there has been no malaria as a result of it, because the tide flowing in and out has kept the air clear of malaria all the time. No man can foretell the effect of the proposed change, or what the result of a dam is going to be. If you place a dam across this river you cannot foresee the consequences. It may or may not be injurious to public health. It will be going into an unknown experiment. We are asked to make an experiment, and what are we going to make it for? What do we expect to gain by it? That I shall speak of later. I spend the summer in Boston, and I know something about how it is here. Take a hot afternoon in August, as I have so many times, and stand on the Harvard bridge and watch the river when the wind is blowing over it. It is cool and refreshing in the hottest days. The breezes blow over the whole crowded North End, among those people who can never go away, and it is all the air they can get from the sea shore

and salt water; and yet people want to change all of that into fresh water, with not merely discomfort, but positive danger to health. Everybody knows about the Board of Health, and what autocratic powers they have. In every case of disease, or possibility of disease, whether it is really dangerous to public health or not, the pettiest official of the Board of Health can come into your home and order you to do this, that and the other thing, and you have got to do it. The police of Berlin or St. Petersburg are not more arbitrary than the Board of Health and their officials. Now, if the Board of Health is so particular as to every item of health, how can they take such a risk in a matter of such great importance as this, and turn the river into fresh water, with the flowage and the sediment settling to the bottom,— how can they come forward and say that this thing can safely be done? The explanation of the conduct of the Board of Health I propose to come to in a few minutes.

I want to read to you a few words showing how Mr. Viaux, the president of the Cambridge Embankment Company, views this proposition. This is from the report of 1894. He says: —

One point has been brought out at this hearing which is a very important one, as it seems to me, and that is in regard to the temperature of a fresh-water basin. The gentleman from the Institute of Technology says that there will be a difference of temperature of 15°. Any one who is familiar with this basin knows that one of its attractions, one of its great charms and one of its great beneficial works, is the summer breeze that blows down the basin. That breeze is almost constant. Even in the hottest and muggiest days of August there is a breeze blowing down the Charles River basin, and that makes that stretch on the Charlesbank so delightful. In those hot, close nights the people pour out on the Charlesbank and on the West Boston bridge, — and they ought to go on the Harvard bridge, which is in summer the most charming walk in Boston, — and get those breezes that come down over the salt water. If you are going to make this breeze 10° or 15° warmer, it is going to operate to the great disadvantage of a large part of the community.

Let me turn to the hearing in 1866, and read the words of Dr. Oliver Wendell Holmes. He said: —

I know something of the people in Charles Street and its neighborhood, and I know that the air which comes over this sheet of water is the very breath of life to them in the sickly season. West Boston bridge, where the breeze is most felt, is a kind of out-of-door, open-air hospital. You may see the poor mothers carrying their little children out in their arms towards the close of any sultry day, to let them breathe the cool, fresh air from over the salt water.

Then comes a letter from Prof. Louis Agassiz to Dr. Holmes, in which he says: —

MY DEAR DOCTOR: — Few cities are blest with such an approach. . . . And what shall I say of the salubrious influence of such a large sheet of sea water, soothing, invigorating and refreshing its surroundings? Is it possible that there are men so entirely ignorant of the value of such natural advantages, or so insensible to the sanitary condition of their fellow citizens, as seriously to propose to ruin this spring of health, comfort and enjoyment? I hope such vandalism will not be tolerated.

Very truly yours, LOUIS AGASSIZ.

Now, then, we will come to the harbor. Of course I do not know anything about that, but I only want to present to you the seriousness of the question of possible injury to Boston harbor. Fifty years ago I was a clerk in the office of Admiral Davis, then Lieutenant Davis, who was then at the head of the Coast Survey Commission for Boston harbor.

The CHAIRMAN. Not the head of the Coast Survey.

Mr. BRADFORD. He was the head of the Nautical Almanac office. I am not familiar with the government arrangements, — not the head of the Coast Survey, but he was one of the Board that was surveying Boston harbor, and I used to hear him discuss these questions then. Now, I want to read to you the words of the decision of the Harbor and Land Commission. They went all through this thing and heard all the testimony in regard to this proposition. The gentlemen here who bring up this matter say that it is different, because they do not propose to build a street outside of Beacon Street, and because they intend to build a different kind of dam. But the report of the Harbor and Land Commission turns upon the dam, and covers any kind of dam. They say in their report, at page xix: —

Moreover, this Board is powerless to say, on the imperfect information it has, what effect a dam as proposed would have on shoaling in the upper harbor. We must, however, record the opinion *that nobody knows what the effect would be.* Upon a careful consideration of the testimony presented, and of all the evidence within the knowledge of the Board, we are unable to find consequences of building the proposed dam as at all certain of being foreseen; and in view of the incalculable injury which might ensue from impairing the usefulness of the harbor, we are unable to report in favor of the recommendation contained in the report of the Joint Board.

Therefore they take that position distinctly, — not that it will be any injury, but that nobody can say that it will not

be an injury, and that is the point that must be kept in mind all through. I believe it is absolutely incapable of proof that it will not be an injury. Then again we come to the question: "What is it all for?" "What are we taking this great risk for?" That question I shall come to presently.

Now, take the cost of this dam. If it does not cost more than $1,000,000 to construct it, it will be different from public management generally. Then we will allow another $1,000,000 which will be needed in the construction of sewers and such things to do the work which the Charles River does for nothing. That makes $2,000,000; at 3 per cent., that will be an expense of $60,000 a year. Then there will be another $10,000 required for keeping them at work, — that will be $70,000 a year. Now, taking into account ice and stormy weather, there are certainly not over 200 days in the year when the basin could be used for the purposes of boating, and 200 divided into 70,000 will give you $350 a day. That is to say, the State and city are asked to hire that basin at an expense of $350 a day for the privilege of boating there. I should doubt very much the advisability of doing any such thing.

Now, as to this collapsible dam. There seems to be a good deal of uncertainty as to what sort of a dam it is going to be. Mr. Dabney tells you it is a collapsible dam, and Mr. Matthews resents that with some vigor; he says that he has made suggestions as to that, but does not propose a collapsible dam. But supposing the dam is constructed with sluices. The sluices will not clear the water. The water in the basin will be a brackish water, and only the free flowing in and out of the tide will keep it salt and clear and pure. Now, supposing they do mean to have this collapsible dam there, what guarantee have you that, fifty or a hundred years from now, there will not be changes, and that it will not be kept closed? Supposing it is a collapsible dam, you have got to have a staff there to work it regularly; and is there anything in our city administration that offers any guarantee that it will be done regularly and at proper times? What security is there of that? You not only have to keep in mind what this dam can do, but what it will do, and what the administration of it is liable to bring about. You have got not merely to consider its structure but its operation for half a century to come, — that is the thing you have got to keep in mind all the time. Mr. Dabney makes the concession that he is willing to have a half-tide dam. That is giving the whole thing away, be-

cause only the top water would be changed, and the water below the level of the half-dam would receive all the sediment and deposit. One of the men stationed at Harvard bridge was at my house the other day and said: "I wish you could see what came from the Fenway the other day; a thick field of black mass just like the contents of water-closets came floating down the river." That is liable to be so at any time. They say that the river is offensive at low tide. It is somewhat so, but do you suppose you are going to get rid of it by covering it up? You will not get rid of it in that way. All the offensive matter that now comes there is going to be there just the same, and it is going to make a smell, and you are going to have just as much offence afterwards. That seems to me to be beyond all question.

Now I have got to come to something that it is not at all pleasant to say. The decorous and dignified way is undoubtedly to make an argument on these matters without saying anything in particular about anybody, but that is not sufficient in this case. When the science of attack has outrun that of defence, the only chance of success is in a counter attack. There is no doubt that if the Boers in South Africa had limited themselves to the defensive the war would have been over long ago, but they have achieved those results which amaze the world by carrying the war into the enemy's country. I now propose to submit a statement, and the proof of it, — that three-quarters of the effort to procure this dam on Charles River have proceeded from the city of Cambridge and the towns above, and, behind them, from Harvard College, while the impulse from Boston has been little or nothing, except as it has been worked up from those quarters. To judge of this, let us follow the course of the whole matter. First let us take the investigation of 1894, and see how it was started. There was a report of the Joint Board of Health and Metropolitan Park Commissioners. Let us see how that Joint Board was constituted. First you will notice the name of Henry P. Walcott, chairman, and then there is one member from Lawrence, one from Marlborough, one from Warren, Wareham and Pittsfield and Quincy. There was but one member of the Board, a physician, from Boston. Therefore I say that Board was practically the chairman, and those who know Dr. Walcott know that when he is chairman of a Board, and wants anything, it goes. Added to the State Board of Health is the Metropolitan Park Commission. I have nothing but respect for those gentlemen, for they have given

to the city and the State perhaps the most magnificent system of parks in the world, worth the money cost ten times over; but their whole attention is occupied with parks, — their business is not specially to give consideration to questions of the harbor, or sanitary conditions, but to give beautiful parks to the people. Please to note that. When they got together, Dr. Walcott still continued to be chairman of the Joint Board. When they came to make their joint report to the Legislature, they offered the testimony of two experts: one was the testimony of Mr. Stearns, the engineer who expected to have the building of the dam if the scheme was carried through; and the other was the landscape gardener, who expected to get the laying out of the whole park, the beautifying of it, if the scheme was passed. Those gentlemen may have been entirely fair about it, but I submit that, when you come to consider evidence in these matters, interested parties who are expected to have the job are not the ones who should be employed as experts. Mr. Stearns came forward himself, — and I can turn to the pages wherein he said he had little or no knowledge of Boston harbor from personal observation, and he rather sneered at the reports of the United States engineers. He did not pretend to have any technical knowledge of Boston harbor. Those two experts were practically all that were offered during the whole hearing.

Now let me sum up this part of the case. Dr. Walcott is an honored citizen of Cambridge, and, while President Eliot was absent in Bermuda, was acting president of Harvard College. There you have the key to the situation at once. I do not for a moment charge him with doing anything dishonorable, — not in the least. What I do say is that he was biased, — that he saw everything from the point of view of Harvard College, and not of Boston. The case for the petitioners was conducted by three men, one from Watertown, one from Cambridge and one from Newton, and the aggressive effort in behalf of this project was from those three points entirely. The defensive was taken by three men from Boston, with one from Cambridge; and as a result the defence was on the side of Boston, and the attack was from Cambridge and towns up the river. Thirty-one witnesses were examined. From up the river nine were for the dam and two against it; from Boston nine witnesses were examined, eight against the dam and one in favor of it. Thus the whole up-river way was practically for the dam, the whole of Boston was practically against it. Of the experts there were ten, three in favor of it and seven against it; so

that you see the comparative weight of evidence on the two sides.

Now we will come to the present state of things. Of the gentleman who is really the foundation and basis of this movement I wish to speak with all possible respect, — Maj. Henry L. Higginson. I knew his father in business for many years, and he was always a gentleman and a man of honor. The record of the son any man might well be proud of. If he has no higher title than major, it was because he was incapacitated by wounds while serving in the civil war. He then went into State Street, into the firm of Lee, Higginson & Co., and raised it through his brains and energy from the moderate condition in which it was thirty years ago up to one of the first of the private banking houses in New England, and a gold mine. And he has used his wealth magnificently. He is full of public spirit in every way. For myself, I am indebted to him for twenty years of uninterrupted enjoyment of one of the finest and largest orchestras in the world. But he sees the interest of Harvard College through the small end of his opera glass, and the interest of Boston through the other end. He has given to Harvard that magnificent Harvard Union, which is such a grand thing for the University; has given to it the Soldier's Field for a playground, which would be very much improved by taking the tide away; and he has now set his heart upon securing for the University a rowing park which shall be kept free from currents and at an equable level all the time. There is the beginning and the end of the whole enterprise; and, with his business habits and his ways of accomplishing whatever he sets his heart on, it is safe to say that the obstacles will be very difficult indeed that he cannot overcome. As far as money obstacles are concerned, they will be nothing. If $100,000 is necessary, it will be forthcoming, — and I don't mean in any wrong sense, either. Take, for example, the great amount of space that you see given to this project in the daily papers. We all know that you cannot put whole pages of reading matter and large pictures of the Alster basin and the Thames into the morning papers, with text appropriate, for nothing.

Mr. Youngman. Pardon an interruption. That question has been raised many times before by editors of outlying papers, coming to me as junior counsel. Every line that has ever been published and every cut about this Charles River basin has been published free, and the newspapers have sought the pictures and made the cuts themselves.

Mr. Bradford. I think it is very likely, because it fur-

nished them with good material; but I fancy they were a good deal more eager to get the cuts and the text with the great firm of Lee, Higginson & Co. behind them. You have only to examine the advertising pages of the daily papers to see the difference that would come in that. I do not say in the least that there will be any dishonorable use of money; but I do say that if money will do it, it will be poured out without stint.

Next we come to Mr. Storrow, a member of the boating fraternity when in Harvard, and who is, if I understand it, a partner in the banking house of Lee, Higginson & Co.,— is he not?

Mr. Youngman. He is now.

Mr. Bradford. I don't know of any situation more promising to a young man than that. Therefore we see the source of enthusiasm here, and why one may be willing to go around and lecture on the advantages of the Charles River dam. Not but that it may be all done with the greatest spirit of integrity, but it weakens the evidence. In any court of justice the evidence would be discounted considerably when it comes from such a source.

Then we come to His Honor Ex-Mayor Matthews, who I understand does not now appear as such, or officially, but as paid counsel, and I have no doubt the honorarium will be entirely satisfactory.

We come next to the question of Harvard College,—because we might as well face it at once. If there is any man who has reason to be grateful to Harvard College, I have. I have never hesitated to say that the four years that I passed there were worth any eight of my life, and the assistance I received there when I was too poor to furnish it myself I shall remember always with gratitude; but when it comes to taking away our river basin, our Naboth's vineyard, then I think it is time to revolt. It is not that I love Harvard less, but that I love Boston more. See the influence that is piling up here. There is nobody who dares to stand up against Harvard College at all. It is an institution of which the whole State is proud. It has two sides to it: one is the educational side, of which nothing needs to be said; the other is the material side. Those millionaires and their sons, who come there and enjoy themselves, go away ready to give, give, give to any extent in regard to it,— $5,000,000 just put in for the Medical School. In this country millionaires are not much thought of for themselves, —perhaps with wonder and admiration, perhaps with some envy and jealousy; but the millionaires in Harvard College

are forming a class that is rapidly crystallizing into an aristocracy. The Harvard Quinquennial is the nearest approach to Burke's Peerage that we have in this country; and I notice that the German Emperor William telegraphed to Prince Henry, — and I was much struck with it, — congratulating him on having received "the highest honor that America has to bestow." Now, the people who hold in their hands "the highest honor that America has to bestow" are not very patient of opposition. They do not like to have anybody stand in the way. Therefore my gratitude to and respect for President Eliot rose 100 per cent. when he came before this committee and told them that what they had to keep in mind was the health and happiness of 400,000 people. If the committee will keep that in mind, I think they will see their way clear to do what is right and proper in the premises. President Eliot mentioned Marine Park and the North End Park and Revere Beach; but he saw clearly enough that this proposition would cut off the very things which make those places so attractive, and these are, the salt air and the salt water, and the tide. I imagine it was for this reason that he only put into his remarks on the immediate topic the five words, "the big improvement of Charles River basin," and my respect for him went up very much from that time forward. The question is simply and solely this: Harvard College, with its rowing basin, on the one side, and the 400,000 people on the other side, and I am very much afraid that the 400,000 people have got to look to this committee for their protection.

I don't wonder that the petitioners have put all their strength into this proposition now. Now is the time when they can achieve it, if ever; because the President of the United States, the outgoing and incoming Secretaries of the Navy, both of the Senators from Massachusetts, and, I suppose, some of the members of Congress, are all loyal sons of Harvard, while, with one or two possible exceptions, none of them are especially interested in the effect of the project upon Boston harbor. I believe the Secretary of War has charge of these matters of harbor lines; and the difficulties will be just now at the minimum. Now is their time to strike, and to strike hard. But see what you do!

Now as to this harbor line, — and by the way I forgot to mention that Mr. Cox, the chairman of the Cambridge Park Commission, said that there were 309 acres below Cottage Farm on the Cambridge side which could be made from an eye-sore into a beauty spot. Why don't they do it by filling them up, as was done on the Back Bay? Because it is

cheaper to do it at the expense of Boston, — cheaper to take the tide away from it. The enthusiasm of the gentleman carried him so far that he thought that Congress ought to give over the management of the Charles River to the Commonwealth of Massachusetts. However that may be, Congress in 1888, I think, seeing these great encroachments on the harbor, took the matter into its own hands, and proposed to establish harbor lines, which could only be changed by consent of the Secretary of War. Now, these harbor lines begin a long way down at Neponset, Cohasset, or wherever it may be, and run all around the city through East Boston and Chelsea and Point Shirley and down to Lynn, more or less, and along the whole distance are private interests, pressing all the time to push out into the harbor. Among the rest, the steam railroad systems have now concentrated into three lines, — the Boston & Maine, the New York, New Haven & Hartford and the New York Central. Take the New York Central alone, — what a business they can create! What a beautiful port it is for shipping abroad! What fortunes they can make, if they can buy land, build out wharves and turn freight from the west to this port! And the New York, New Haven & Hartford is planning to do the same thing. Now, those railroads will be pressing with all their might to get over the harbor line; and I think that, much as is the influence of Harvard, the influence of the railroads is greater, and they are going to press, too. If you think it is going to stop here, you are mistaken. If you break the line once, if you get the precedent established, that you have, for convenience or beauty or anything, broken this line, the whole fabric will go down, and you will have no protection for your harbor; and thus, at the moment when we are going to Congress to ask for an appropriation of $8,000,000 or $10,000,000 to clear out the harbor channels, we are planning to do what all the United States authorities say will injure the harbor. Mayor Matthews, in one of his speeches, said that the bottom is going to be of rock, and he wished to know how the scour would affect it. It is not the rock that needs to be scoured, but what is deposited on the rock. He said, further, that if it did fill up, it could be dredged at light expense. After we have gone to Congress and got all this money to clear the harbor, and we then fill the harbor again, we can dredge it.

If this project is carried out, it is going to break up all the harbor line and unsettle everything, and give us no protection whatever. The only way to do is to hold to the

harbor line as it is now. If those gentlemen are so sure that this project is going to beautify Boston and the Charles River, so sure that it will not injure the health of the city or the harbor, why don't they ask for a vote of the population of Boston on it; or, if that is not satisfactory, why don't they take the vote of Suffolk County and the towns up along the Charles River? They dare not do that. They know that it would be buried deeper than the ruins of ancient Egypt were buried under the sands of the desert. It seems to me that, if ever there was a time when there should be such a referendum, it is now; though I confess that, if I thought there was the slightest danger that the people would vote in favor of it, I should be the last to urge it. If it is a popular measure, let that fact be found out now.

I think that the protection of the city and of the harbor and of the people and of the harbor line rests with this committee. The influences on the other side are so powerful and so great that I do not see how they can be resisted, and I have very little hope of any other resistance. There is just one thing I desire to say to show you with what timidity everybody is afraid to stand up against this influence. If there is anybody interested in the harbor, it is the Board of Trade and the Chamber of Commerce. I don't believe you can find a single member of either, not a graduate of Harvard, who is not opposed to a dam or anything approaching a dam. Last year those Boards came forward with a protest against a dam being built; but when it was said that there was to be a collapsible dam (about which Mr. Matthews now seems to be in doubt) and that it would not injure the harbor, then they had nothing to say. Knowing the forces that were to be brought to bear in favor of the construction of the dam, and not knowing how this committee was to be constituted, I asked to be allowed to come before them, as I did on one other occasion, and address them on the present case, but they said they had no interest in the matter except as regarded the harbor. I said that was precisely the matter on which I wished to be heard. To this I received a civil but cool reply, — that I had better come before the commission or somebody else; and it is because they will not stand up against this powerful influence that I am here. That is exactly the thing we have to contend with. I feel very guilty at taking up so much of your time, but, as I said, it is a question for generations, and therefore I must do it, if no one else will.

Mr. Youngman. Will your commission permit me less

than sixty seconds to state one or two facts about the boats and the rowing of the Harvard men? This basin, if used as a water park, would be a detriment rather than a benefit to Harvard rowing. At present the Harvard men have a monopoly of the river. Their boats are very light, — an 8-oar, carrying 9 men, only weighs about 240 pounds, — and the men can easily make it go at the rate of 12 miles an hour. They are out for exercise, they are in costume, so the currents are of little or no consequence to them, except in the matter of comparison of time taken in time rows. They have nothing to obstruct their progress now; but if the basin were very much used, they would have, if the water were kept as it is up at Riverside, boats in their way all the time. Certainly they have no special desire, as far as that part of the thing is concerned.

Mr. BRADFORD. Do I understand that the young gentlemen of Harvard do not favor the project?

Mr. YOUNGMAN. I think they favor it, but from broader reasons than those stated.

Mr. DABNEY. How about one at Cottage Farm? Do they favor a dam at Cottage Farm?

Mr. YOUNGMAN. They do not.

Mr. BRADFORD. The point is this. It is not the current rowing; what they want is to have their great celebrations there. You know how that will be. When the football game took place last year there were between 30,000 and 40,000 people there to see it on Soldier's Field, and the business of Boston was almost suspended that day. On attempting to attend to some slight matters of business, I found everybody was either at the game or out watching the returns. Even ladies came from all over the country, and in cold November afternoons they will sit there two or three hours to see the game, — not because they care about the game, but simply because it is conducted at Harvard. In fact, I understand the game is not equal, as such, to that conducted by professionals, — but it is at Harvard. What they want to do here on the Charles is what they now do at New London. If they could have a dam put across there and have the basin filled up and kept at a level, you could have the most tremendous show there. Why, the place where they row on the Thames — Henley? — wouldn't be a circumstance to it. The reputation of it would go all over the world. That's what they are after.

Commissioner DANA. Do you think Yale would give consent to come up and row their races on the Charles?

Mr. BRADFORD. Why not? They come here to play

football. I think they would be delighted to come. I say it is impossible to avoid the conclusion that the pressure on this subject is from Cambridge and Harvard College, and not at all from Boston.

The CHAIRMAN. The committee would like to ask if there is anything further that any gentleman present desires to say.

Dr. BARNES. I assume you do not care to hear anything from other members of my committee, in view of my statements.

The CHAIRMAN. I think not, sir. If there are none who care to speak, the committee will adjourn the hearing at this time.

The hearing then closed.

OBSERVATIONS IN REGARD TO THE IMPROVEMENT OF CHARLES RIVER.

By J. Herbert Shedd.

In considering the influence upon Boston harbor of the proposed damming of the tidal flow of Charles River, it will be well to review to some extent the present condition of the harbor and the influences which affect or control the currents, and also the possible shoaling or scouring now obtaining.

It will be convenient to consider the harbor as composed of three sections: (1) the inner harbor, lying north-westerly of Castle Island and Governor's Island; (2) the middle harbor, lying north-westerly of Long and Deer islands; and (3) the outer harbor, lying westerly of Point Allerton and the Brewster Islands.

The fresh water which flows from the rivers into Boston harbor does not furnish an important aid to keep the channels open. The average annual flow of all the rivers which discharge into the harbor above the line of the East Boston ferry is equal to about .92 of 1 per cent. of the volume of the tidal prism above that line reckoned on the outflow for one tide. As the fresh water is backed up by the flood tide and added to the flow of the ebb, the effect is to double its flow, and therefore add to the ebb about $1\frac{4}{5}$ per cent. of fresh water to its total volume. Of the volume of the tidal prism going out of the inner harbor, covering Bird Island flats and limited by Governor's Island and Castle Island, the total amount of fresh water, doubled on the ebb, adds about $1\frac{1}{3}$ per cent. to its total volume. For the freshet months of the year the amount of fresh water, doubled, would be $3\frac{7}{8}$ per cent. above East Boston ferry, and for the dry months the amount would be about .4 of one per cent. For the inner harbor the freshet percentage would be about $2\frac{1}{3}$, and for the dry months it would be about $\frac{1}{4}$ of 1 per cent.

An examination of the tide tables published by the Coast and Geodetic Survey shows that the flood tide sometimes exceeds the ebb in the time of running; but on the whole, for the year, the running of the ebb tide exceeds the flood about 4.8 minutes on a tide, or about 6 hours and 10 minutes for the flood tide and nearly 6 hours and fifteen minutes for the ebb. This difference of time in the run of the ebb, supposed to result from the addition of fresh water amounts to about 1.3 per cent. of the time of flood. Whether we consider the effect of the fresh water from its relative volume or from the increase in the time of the discharge of the ebb over that of the flood, it is equally clear that its importance is very slight. Whatever the effect of fresh water may be, the erection of a dam across the river will not tend to lessen the fresh-water flow of the Charles.

The fact that the prevailing force of the ebb tide is, on the whole, slightly stronger than the flood, does not indicate that the scouring efficiency of the ebb is uniform in its effect in different parts of the harbor or in its channels. It has been customary for the United States Coast Survey to publish on its charts of Boston harbor a table of tidal currents, giving for twelve stations the set and the drift of the tides for the first

quarter, the maximum and the third quarter at each station. It appears from this table that on six of the stations the average drift of the flood is greater than the average drift of the ebb, and for the other six stations the reverse is true. At one of these stations the set for the first quarter of the flood is exactly opposite the set for the maximum of the flood. In only two instances of the entire table, or in two of the thirty-six records, is the set of the ebb exactly opposite the set of the flood. This difference in the set, or direction of the flood, and the ebb, with reference to the thread of the channel, tends to dissipate the resultant of the scour which might otherwise be expected to check the deposit of suspended or rolling material in the channels.

The following table is a copy of that published on the United States charts of Boston harbor, to which I have added a column, giving an average of the drift for each tide. The Boston harbor charts issued by the United States Coast Survey from 1857 to 1872 give the locations of the twelve stations where the observations were made.

Tidal Currents. — *Table of Current Observations made in Boston Harbor and Vicinity by Lieut. Com. C. H. Davis, U. S. N.; A. D. Bache, Superintendent United States Coast Survey.*

No.	STATION.	FIRST QUARTER.		MAXIMUM.		THIRD QUARTER.		Average Drift for Each Tide.
		Set.	Drift.	Set.	Drift.	Set.	Drift.	
1	Three-eighths mile south of Bird Island.	N. 54 W. N. 63 E.	.8 .8	N. 54 W. N. 64 E.	1.3 1.2	N. 54 W. N. 70 E.	.9 .7	1.00 .90
2	Three-eighths mile north of Spectacle Island.	S. 81 W. N. 60 E.	.6 .7	West. N. 64 E.	.9 .9	S. 83 W. N. 70 E.	.7 .7	.73 .77
3	West of Long Island Lighthouse.	S. 43 W. N. 30 E.	.5 .4	S. 12 W. N. 69 E.	.7 .9	S. 8 E. N. 53 E.	.3 .4	.50 .57
4	Between Long Island Lighthouse and Deer Island Beacon.	N. 81 W. N. 85 E.	1.4 1.4	S. 63 W. East.	2.5 3.3	N. 77 W. N. 84 E.	1.2 2.1	1.70 2.27
5	Between Lovell's and Gallop's islands.	S. 45 E. N. 45 W.	.3 .2	N. 45 W. N. 20 W.	.6 .9	N. 45 W. N. 18 W.	.4 .5	.43 .53
6	Between Barrel Beacon and Centurion Buoy.	S. 67 W. N. 60 E.	1.0 .6	S. 54 W. N. 56 E.	1.5 1.2	West. N. 70 E.	.6 .7	1.04 .83
7	North of Peddock's Island.	S. 58 W. N. 58 E.	1.1 .8	S. 60 W. N. 54 E.	2.1 1.3	S. 60 W. N. 63 E.	1.4 .6	1.53 .90
8	Between Boston Lighthouse and Point Allerton.	S. 76 W. N. 86 E.	1.3 1.0	S. 76 W. N. 88 E.	1.6 1.5	S. 73 W. East.	1.2 1.2	1.37 1.23
9	West of Great Calf Island.	S. 44 W. N. 18 E.	.6 .5	S. 33 W. N. 42 E.	1.0 .6	S. 36 W. N. 40 E.	.6 .5	.73 .53
10	Broad Sound Channel.	S. 42 W. N. 47 E.	.6 .8	S. 29 W. N. 47 E.	1.1 1.1	S. 43 W. N. 52 E.	.7 .6	.80 .83
11	Between Outer Brewster and the Graves.	S. 18 W. S. 80 E.	.2 .3	N. 84 W. S. 80 E.	.3 .5	N. 80 W. S. 80 E.	.2 .4	.23 .40
12	South-east of Nahant Point.	S. 63 W. N. 50 E.	.3 .2	S. 72 W. N. 69 E.	.4 .4	N. 88 W. N. 46 E.	.3 .2	.33 .27

NOTE. — The observations were made as far as practicable when the influence of the wind was small. The set is expressed in degrees from the true meridian; the drift, in nautical miles per hour; the maximum set and drift are represented at the stations by ——→ for flood, and ——→ for ebb. At Station No. 5 the first quarter flood is represented by ——•——→ and the maximum by ——•——•——→

Forming a part of the book of tide tables of the United States Coast Survey are current tables, and from those current tables I have selected the records from the eight stations situated in the inner harbor, and plotted them so as to give a graphic representation of the set and drift, and also have shown the approximate line of the channel at each station. The two diagrams on which these records are plotted are presented. The variations from uniformity in the direction of flood and ebb currents may be readily seen.

That the United States Commission recognized the want of definiteness in the scouring effect of the ebb tide may be seen from the following quotations from their tenth report, 1866: —

"Boston upper harbor presents, as one of its worst features, a flood predominance in a portion of the main channel, — that portion which lies between Bird Island and South Boston flats. The upper middle bar, upon the one hand, and the anchorage shoal, upon the other, are the limits of this flood channel. These two banks, are in fact, the debatable districts where the flood and ebb are equal in power. . . .

"If we may not assume that these two banks which limit the flood channel have been formed in the contest of the ebb and flood forces, and that they are the sediments thrown down in the equal contests at their equilibrium points, we can at least assert that these banks are in no wise to be regarded as *causes* of the phenomena observed; and we see no reason to doubt that, if the conditions should be changed so as to give entire mastery to the ebb, these banks would diminish, if not disappear. At present there are no causes at work to wear them away; quite the contrary; we cannot see how *rolling* material can pass them.

"The upper middle bar is hard clay, — a material which we have never seen *accumulate* at equilibrium points, and the anchorage shoal is not, as far as known, formed by rolling material. In the form of the anchorage shoal we recognize indications of a solid nucleus, — a boulder, perhaps; but even this would have been undermined and lowered in position, if the currents had had any resultant power with which to scour the bottom."

As illustrating in another way the change of conditions in the flow of the tidal current at the entrance from the sea to the inner harbor, reference may be made to the current tables before referred to, published in the book of tide tables of the United States Coast Survey. It is generally true that the tidal current continues to run both on the flood and the ebb for a longer or shorter period after the turn of the height of the tide at high or low water. But at Station 8, north from Castle Island wharf, bounding on the east the section where the drift of the flood tide is stronger than the drift of the ebb tide, the flow of the flood current ceases at the time of high water and the flow of the ebb ceases at low water. To the extent that the ebb flow continues beyond the time of low water at any point in the harbor above this station 8, in case the water contains or transports sediment, there results a positive injury to the harbor, for the reason that the resisting currents cause that sort of commotion which is favorable to the settlement of the sediment, and checks the outward transport of material upon the bottom. The United States Commissioners found, and stated in Table 1 of their tenth report, 1866, that the ebb continues after low water forty-five minutes at the Navy Yard, and the slack between ebb and flood as thirty-five minutes more, making a period of one hour and twenty minutes before flood begins after low water. The remedy for this injurious condition which is most readily available would be to shut off at least the last portion of the run of the ebb tide, — say for a depth of 2 feet; which could be conveniently done for the Charles River portion, if a dam existed by

means of which the outflow of the tide and river water could be controlled.

The element of time alone does not completely represent the injurious effect of the late run of the ebb tide; there is, in addition, an acceleration in the rate of flow at that time. The United States Commissioners, in their tenth report, 1866, say: —

"What we have said of the epochs of the slack currents also applies in a more remarkable degree to those of maximum flow. The ebb at the junction of the two rivers does not acquire its greatest rate of flow till one hour before low water, so that, when the tidal current at the mouth of the harbor has commenced to run flood, that of the main channel of the upper harbor has a considerable velocity in the direction of ebb. The upper harbor is hence a scene of conflict, or at best that of opposing forces, neutralizing each other at time of low water."

And again they say: —

"In the Castle Island narrows (the main avenue to the upper harbor) the flood commences twenty-five minutes after low water of Navy Yard, or twenty minutes before the ebb at the rivers' junction has ceased, and nearly one hour before the flood at the junction commenced. For nearly one hour the basin of the upper harbor is either a vortex of opposing streams or a neutral ground for the deposit of sedimentary matter. It thus appears that the most valuable portion of Boston harbor is made the site of the most serious antagonism and the most feeble efforts of the tidal currents."

While the tendencies of the currents of the harbor are indicated in what goes before, the importance of these currents should not be overrated. The United States Commissioners, in their report next above quoted, say: —

"The currents of Boston harbor, it may be seen, are very sluggish, considering the great rise and fall of the tide; and the very fact that they are so, indicates the insignificance of the reservoirs above."

The results of experiments by Bossut, DuBuat, Login and others, upon the velocities in the flow of water needed to move materials of different natures, have often been quoted. Some, if not all, of the experiments were made with thin sheets of flowing water, say half an inch deep or less, and it may be doubtful if such results can be safely applied to currents several feet in depth. It must at least be supposed that it is the bottom velocity of the deep channel which is to be considered, and not the velocity of the surface flow.

Major C. B. Sears of the United States Corps of Engineers has said: —

"Engineering authorities give a number of tables of current velocities necessary to move certain materials, as sand, mud, clay, gravel, etc. These tables are approximately alike, and the velocities given by them, especially DuBuat's, are, I think, all too small to be relied on in practice. They are generally founded on experiments in smooth troughs or small channels, with both material and water in small quantities. In practice we have to deal with both, in large masses and moving over irregular surfaces. My own observation leads me to believe that the tabular velocities in practice should be doubled, at least, in calculating definite results to be expected from increased current velocities; *i.e.*, instead of expecting fine sand to be scoured out by a current of ½ mile per hour, the engineer had better plan to raise the velocity to 1 mile an hour, and then give his stream a generous amount of time wherein to do the work."

In the tables of results of experiments above mentioned a current of .17 mile per hour is said to just begin to work on fine clay. It ap-

pears that this was "brick clay when mixed with water and allowed to settle for half an hour." Login found it to be true that such clay would be moved by a current of .17 mile per hour; but he also found that "brick clay in its natural state was not moved by a current of 128 feet per minute, or 1.45 miles per hour." It is not often that this latter velocity of flow or drift has been found in Boston harbor. The greatest mean velocity in the harbor, mentioned by the United States Commissioners, in their tenth report, 1866, so far as I recall, is that of Nantasket Roads at half ebb, which they give as 1.3 miles per hour; and in regard to this channel the commissioners say: —

"Nantasket Roads is the conduit for the tide of more than one-half of Boston harbor, and the Broad Sound Channel for the remainder, unless we regard as worthy of consideration the Black Rock Channel, which is traversed by a small but rapid stream which crosses the main ship channel, and co-operates, as far as may be, with the stream of Nantasket Roads, in the filling and draining of Quincy Bay."

And they add just here a note in regard to the main ship channel, as follows: —

"It is a very remarkable circumstance that the main ship channel here is traversed by no current along its course; and we have tried in vain to conceive by what disposition of forces it was first created. That it must once have been dug out by a tidal stream would seem evident, from the form of its bed and banks."

In order to make the study of the action of currents in the harbor specially useful, it will be necessary to consider in the same relation the source and movement of sediment and other materials which might by deposits cause shoaling in channels or other important portions of the harbor.

I do not find evidence that, upon the whole, there has been shoaling in the channels or other important portions of Boston harbor, except among the islands of the outer harbor; but there have been important changes in the position of banks and channels, due to the shifting of deposits from place to place.

Extensive studies were made by the United States Commissioners, and continued, under the advice of the United States Council, by the Harbor Commissioners, in relation to changes in the bed of Boston harbor. Two general results were reached, and were stated as follows: —

"1. In the clear water way of the upper harbor the volume has remained the same.

"2. The changes that have occurred are those due to the transportation of mud, sand, etc., from one portion of the harbor to another."

The Harbor Commissioners, in 1867, obtained, through Professor Peirce, the services of "Mr. L. F. Pourtales, an accomplished naturalist, to examine our specimens of the harbor bottom and report upon them. His report, now on our files, frankly states his inability to discover the recent sources of the material forming the shoals and bars, but contains a valuable discussion of the physical features of the harbor. In this connection he makes the following statement: 'The islands are generally covered with drift, so that the subjacent rock is rarely exposed to view, except the general strike of the ledges which form this skeleton, by the direction of their longer diameters, or by their arrangement in lines. The direction of the strike is nearly N.E. and S.W. Red lines on the map show the best examples. Thus we have one of these lines passing through South Boston heights, Governor's Island, Apple Island, Snake Island and Winthrop Head. The shoal ground of the upper middle forms part of this system. Then we have Thompson's Island

and North Spectacle Island; next, Squantum, Moon Island and Long Island, the range continuing through Alderidge's Ledge to Green Island and the Graves, Half Moon Island, Peddock's Island, Grape and Bumpkin Island, Strawberry Hill and Harding's Ledge. The examples might be multiplied to a much greater number among the ledges of Cohasset, and still better, perhaps, at Nahant, where the rocks, being more denuded, show both strike and dip very plainly, as was shown to me by Professor Agassiz.'

"Mr. Pourtales' failure to discover the derivation of the deposits is explained, now that we are informed by the inquiries of our advisory council that *the shoaling is nearly all of it a mere shifting of the material,—not deposit from foreign sources.*"

The chief source of material to cause deposit in the harbor is, or was, the many islands of the outer harbor exposed to the action of the sea, and, to a less extent, the shores and flats of the more interior portions of the harbor. The severe easterly storms which not infrequently occur were very destructive on the drift composing or covering the outer islands, until the extensive works of protection were undertaken by the United States government. Col. J. G. Foster, United States engineer in charge of the government work in Boston harbor, gives an account of his work in 1871 which it may be well to recall:—

"The natural boundaries of Boston harbor include all the expanse of tide water lying within a line drawn from Point Allerton to Point Shirley, and extending from that line westward to the shores of the mainland.

"This comprises a surface area of nearly 31,000 acres, from which, deducting the area of the islands within the harbor, nearly 1,000 acres in extent, gives a water area of the harbor of 29,700 acres. This large expanse is well sheltered from the ocean by Point Allerton and the ten seaward islands, among which the most important are Deer Island, Lovell Island and the three Brewster Islands. These islands and the adjacent headlands constitute the natural breakwaters of the harbor, through which the two deep channels, the main ship channel and Broad Sound Channel, pass in such a manner that all vessels, as soon as they are fairly within the portals of the harbor, are within easy access of well-sheltered roadsteads.

"The large interior basin of the harbor is fortunately divided into many excellent anchorages, both for light and heavy draught vessels, by the favorable position of the numerous islands in the harbor. Of the eighteen of these that appear on the chart, the most important, in respect to the protection they afford to shipping, are George's Island, Gallop's Island, Long Island, Peddock's Island, Castle and Governor's islands.

"George's Island shelters the shipping in George's Roads from the easterly gales, and also a part of Nantasket Roads from northerly winds.

"Gallop's Island also affords protection to George's Roads on the north and to the main ship channel on the west and south-west.

"Long Island shelters the President's Roads from the south and south-east storms, and George's Roads from the north-west and westerly gales.

"Peddock's Island protects Hull basin on the north-west, and a large portion of Nantasket Roads on the south. Castle and Governor's islands afford protection to the upper harbor, as the portion of the harbor lying west of Fort Independence is usually termed, in contradiction to the lower harbor, which comprises all the water surface eastward to the entrances.

"The first-class anchorages, under shelter of the above islands, for vessels of 23 feet draught, at all stages of the tide, are as follows: —

	Acres.
Nantasket Roads, containing	1,720
Hull basin, containing	730
George's Roads, containing	490
President's Roads, containing	1,010
Upper harbor, containing	200
Total, ...	4,150

"The above does not include the areas of the main ship channel nor the anchorages north of the lower middle ground. It does include the area of the upper harbor, because it is now connected with the deep waters of the lower harbor, a cut having been made by dredging during the past season entirely through the upper middle bar to a depth of over 23 feet at mean low water. This cut, now only 45 feet in width, it is proposed to widen during the next and following seasons to 300 feet or more, if navigation shall require it.

"Nearly all the islands of the harbor are now entirely destitute of trees. A few remain upon Apple Island, and a small number have been planted on George's Island by the government since the construction of Fort Warren; yet history and tradition both agree in stating that, at the time of the first explorations by the Pilgrims, nearly all the islands were well wooded. Some of them bore evidence of having been inhabited and cleared for cultivation."

The destruction of the trees having been noted and regretted, he says: —

"The extent of the loss as protection for the islands themselves may be estimated from the amount of the resulting injury.

"The sides of the islands and headlands, being exposed to the full force of the winds and their shores to the cutting and dissolving force of the waves, intensified by the lower sweep of the winds, were subjected to gradual destruction.

"The effect of the waves in storms dashing against the exposed shores is evident to any observer; portions of the material of the formation are dislodged by every dash of the waves, and lighter particles, being borne back by the receiving waves or undertow, are either deposited at once in front of the abraded bluff or are carried away by the currents to other points, where, becoming checked in motion, they are deposited to form bars or shoals, encroaching upon the roadsteads or channels. The portions of the material too heavy to be borne by the currents are sometimes driven by the force of the waves along the shores until the moving forces cease or are neutralized.

"As the lighter material is washed away, the boulders fall out, and, rolling down to the foot of the bank, remain there, forming in time an apron of stone, to serve as a protection against further encroachments. Thus the very process of destruction operates in time to protect against further destruction. But the removal of these water-worn and rounded stones to serve as ballast, or paving stones, necessarily exposed more of the bank, to be washed down, until a new crop of stone was produced.

"Whatever the precise character of the action may have been, the results soon became so apparent as to attract public attention and to alarm those interested in the preservation of the harbor.

"Some islands were found to have been entirely washed away, leav-

ing dangerous shoals in their places. Ram's Head, a small island situated 550 yards north-east of the north head of Lovell's Island, and once containing several acres, had entirely disappeared, leaving one of most dangerous shoals at the Broad Sound entrance. Upon this shoal, about forty years ago, the Maine "Packet" was wrecked, and all the passengers, fifteen in number, perished of exposure and cold.

"Nix's Mate, once a considerable island, according to the old colony records, which shows that on the 8th of September, 1636, 'there is 12 acres of land granted to John Galop, upon Nix's Island, to enjoy to him and his heirs forever, if the land be so much.'

"Des Barre's chart of the survey of 1775 shows Nix's Mate to have been at that time an island containing about 6 acres. This island was long since washed away, leaving in its place a shoal, dangerous from its proximity to the main channel, upon which many vessels each year run aground.

"Bird Island shoal, in the upper harbor, was once an island, and inhabited in 1634.

"This washing away of the islands and headlands early called attention to the necessity of the preservation of what remained.

"In the year 1827 an appropriation from Congress was obtained for the construction of a sea wall for the protection of Deer Island, and a dry stone wall was built on the east side of the island, in three sections, covering the three prominent heads.

"In 1843, on petition of the city of Boston, the Legislature of Massachusetts instructed its Senators and Representatives in Congress to exert themselves to obtain an appropriation to further protect the harbor. By their exertions an appropriation of $15,000 was obtained, and expended by Col. Sylvanus Thayer in the construction of a sea wall on the north head of Lovell's Island.

"Other appropriations were subsequently made for this island and Great Brewster Island, on each of which substantial and costly sea walls have been built and maintained by the general government.

"These islands, being the larger of the seaward islands at the entrances to the harbor, were the first to receive the attention of the general government in the way of protection; but the islands lying more westerly in the harbor were also justly regarded as requiring protection, being important as the more immediate shelters for the safest and best anchorage.

"In June, 1856, the Legislature of Massachusetts passed 'An act to protect Boston harbor,' which prohibited the taking of stone, gravel and sand from the islands and headlands of the harbor except by license from the city of Boston."

Extensive hydrographical and physical surveys were made for the city of Boston, and also topographical surveys of the shores of the islands were made by Coast Survey officers. Of the latter, Colonel Foster says: —

"Prof. Henry L. Whiting, of the United States Coast Survey, who made a topographical survey, ascertained the probable original extent of the prominent headlands and islands, by completing the contour curves in a manner analogous to the curves of existing hills in the neighborhood, thus ascertaining the amount washed away. According to his estimates, the little hill of Point Allerton originally extended beyond the present position of the beacon, and was about 100 feet high. It was, at the date of the survey, reduced in height to 60 feet, and had lost by washing away nearly 43 acres. The loss in thirteen years, from 1847 to 1860, had been 22,000 square feet. The loss of the great hill of Point Allerton had been, in thirteen years, from 1847 to 1860, 40,000

square feet. The Great Brewster Island had lost over 30 acres, the encroachments extending to the summit of the largest hill. Two hundred and twenty thousand square feet had been washed away in the thirteen years preceding 1860.

"Deer, Lovell's, Gallop's, Long and other islands had all lost by washing away in a similar manner, but many of them in a less proportion."

In regard to the preservation of Point Allerton Colonel Foster says: —

"This exposed and rapidly disappearing headland should, from its important character, have been protected at the earliest possible day; but owing to the numerous delays in obtaining a deed of the site, and the privilege of locating in a safe place the wharf for landing materials, the work of construction was not commenced until this season. . . .

"In seeking to ascertain where the materials washed away from this point have been carried, and if any have been deposited in the main channel, I caused a careful comparison of all the surveys from 1769 to the present time to be made. The results of this comparison, shown in the comparative map accompanying my letter of April 13, 1870, shows that within the limits covered by the comparative map, extending about 2,000 feet outside of the entrance and 5,000 feet within, covering an area of the main channel of 451 acres, there had been a shoaling to the extent of nearly 5,000,000 cubic yards of material. Were this immense quantity spread out over Boston Common, it would cover it to the depth of 64 feet.

"This great deposit did not probably all come from Point Allerton; in fact, its source can only be ascertained positively by an accurate and minute geological survey, as recommended by Professor Agassiz in his letter of September 11, 1867, published by the Coast Survey report for that year.

"The movement of the curves of depth outwardly toward the channel is, however, a strong indication that much of the shoaling came from the point.

"The comparative map shows a very decided outward movement of the 12, 18 and 24 feet curves, the latter curve having moved out about 1,000 feet. The deeper curves have moved less; some of the deepest ones have, however, been entirely obliterated.

"The 48 and 54 feet curves shown on Wadsworth's map of 1817, about half way between Point Allerton and Boston Light, are entirely wanting on the commissioners' map of 1863.

"The general principles that guided the United States Commissioners in their original investigations and reports upon Boston harbor, and which likewise actuated the Board of Harbor Commissioners for Massachusetts in their petitions and exertions for national aid, were those of *preservation*, and aimed 'to preserve the great physical features in their ancient order, and to hold on to the old landmarks.'

"The reasons were threefold: first, to preserve the islands and headlands, because of their value as shelters to the anchorage grounds; second, because the material washed from them *must be deposited* somewhere in the roadsteads and channels, to the injury of navigation; third, because 'as these bluffs fall back they leave in their places dangerous shoals and reefs, hidden for the most part, especially at high tide, and these embarrass the navigator, even when he is familiar with their existence and whereabouts.'"

The wasting away of the islands and the stirring up of material from the shores and flats furnished water-borne matter which was mainly deposited in near-by places. The lighter stuff, which would remain a long time suspended in water, was carried to greater distances, and

probably to some extent reached the inner harbor and the lower portions of the rivers. Whatever matter came in in this way seems to have been carried out by the ebb tides to a very great extent, and perhaps entirely. The silt brought down by the rivers has deposited more or less in the lower reaches of the rivers, and these deposits have changed in position from time to time. Some matter has been deposited by sewers, and a little matter is thrown into the harbor from the shores and from vessels.

The main sources of the supply of material which might cause shoaling in the harbor being from the shores and flats on the seaward side of the harbor, where they are acted upon by storms through the winds and waves, and which material can only be carried into the harbor by flood tides, it is well to adopt any tendency which may be available to lessen the volume of the flood tide for the interior basins. The cutting off of the Charles River basin, while very small, would still have this favorable tendency, and at the same time the advantage of the flow of the river water, or back water, as it is called, would be preserved for the ebb tide.

So far as I am informed, the men who have done dredging in the harbor consider the material they have removed to have been original formation, and not deposit from tidal action. This is in a measure confirmed by the experience of the Harbor and Land Commissioners and from information they have received from others, as stated in their report, including the report of their engineer upon the subject, dated May 1, 1895, as follows: —

"The only place in the harbor outside of the harbor lines where we have any record of dredging material which might have been deposited since the year 1860 is near the mouth of Charles River and opposite the wharves between Bartlett's wharf and the Chelsea ferry slip, where, in 1886, we dredged large quantities of barrel hoops, sugar mats and like material, which probably came from the cooper shop on Ripley's wharf, opposite."

And later the report continues as follows: —

"Out in the harbor all the material dredged, excepting at the places near the mouth of Charles River previously described in this report, has been of sand, clay, gravel or hardpan; and in the upper middle, in order to get the required depth of water, in many places it was necessary to blast out large quantities of ledge. The channels so dredged maintain their depths, and it has not been necessary to redredge them except in two cases, so far as I can learn. These two cases are as follows: —

"About 1875 the Mystic River Corporation dredged a narrow channel from its dock to the deep channel of Mystic River. The dredged channel was narrow, and at right angles to the current of the river; the material through which it was dredged was fine sand, and in a few years the banks of the excavation caved down and filled in the channel a number of feet.

"The other case is the reserved channel on South Boston flats. The westerly end of this was dredged in 1889, 110 feet wide, to the depth of 12 feet below mean low water, with a temporary entrance 8 feet deep. In 1893 the position of the channel west of L Street was widened to 400 feet, and about 200,000 cubic yards of clay from the upper middle was dumped there and redredged. While this was being done a portion of the material stirred up by the dredge settled in the channel east of L Street, shoaling it about 2 feet."

To the extent that the material in the harbor is shifted from place to place by the local currents, the interests of shipping are more or less

interfered with, and it is desirable to lessen the changes, so far as may be easily done. Ordinarily, the currents are very feeble, but under the influence of storms and freshets it is probable that some motion of the bottom material occurs, and the amount of motion bears some relation to the volume of tidal water involved. If this volume is lessened, the currents will be lessened and the shifting of material lessened. The tidal prism of the Charles River basin is very closely one-seventh of the whole tidal prism above Castle Island; and if this is shut off from flood and ebb, the tendency will be to lessen the local currents, which possibly cause changes in the bottom. The whole effect is believed to be small, but the tendency would be in the right direction, especially as it has been found that the discharge from the Charles River prism is in excess of a desirable amount.

Transformation of Boston Harbor.

In its natural state Boston harbor furnished an admirable basin for the accommodation of shipping of moderate capacity, with many excellent features for the benefit of shipping of the largest class. It may be that in the lapse of time a permanent régime, or balance of forces, had been established, which, in the absence of important artificial changes, would have kept the channels and basins in the condition found by the first white settlers. But the natural conditions were not such as served the purpose of the settlers; they required wharves with water of sufficient depth alongside; the indentations of shallow water within the general shore lines supplied tempting opportunities for improvement for tidal mill sites, or canal basins, or occupation for commercial or business purposes; and the result was, that the water areas were encroached upon more and more as time went on, until a very serious proportion of the inland areas have been reclaimed from the tide, and the volume of inflow and outflow of the tide had been greatly diminished above the inner harbor. Coincident with the general lessening of the volume of the tidal prism, there came a time when deeper and wider channels were required to accommodate the growing size of vessels. The combination of less tidal volume with larger channels through which it passed changed Boston harbor from a natural basin, to be kept open by natural forces, to a highly artificial basin, to be kept open by artificial means. To restore the natural tidal forces and increase them to correspond with the larger channels would be undesirable and quite impossible. Boston harbor in its present state must be accepted as an artificial creation, and treated accordingly. It is probable that in no way can the tidal forces be improved to any important degree for the scouring of channels, except at a cost much greater than that of securing the same effect upon the size of channels by dredging directly at the points where improvements are desired. And there seems to be no good reason to hesitate to make further changes in the tidal volume, where any considerable benefit would result to the community from doing so.

To illustrate the encroachments upon or changes in the tidal areas, the following figures, resulting from measurements upon the best maps at hand, may be referred to: —

Comparison of Tidal Areas.

	Areas in Acres.				Percentage of Decrease, 1857 to 1899.
Edition of map,	1775	1857	1872	1899	-
Charles River to Craigie bridge,	1,757	1,299	1,276	833	35.87
Charles River from Craigie bridge to South Ferry,	722	485	425	258	46.80
Inner harbor,	–	–	2,083	1,658	–
Mystic River,	931	1,029	990	870	15.45
Malden River,	78	59	63	81	—37.29
Island End River,	41	110	104	82	25.45
Chelsea River,	556	522	506	459	12.07
South Bay,	–	–	348	266	–
South Bay and inner harbor,	2,631	2,515	–	–	–
Totals,	6,716	6,019	5,747	4,507	25.12 32.89*
Inner harbor and South Bay,	2,631	2,515	2,381	1,924	26.87*

* 1775 to 1899.

It is known that large encroachments upon the tidal area had been made in the period of more than two hundred years before 1857. Large areas like that cut off by the Mill Dam Corporation, of 564 acres, and the area near Haymarket Square and others about Boston and Cambridge aggregate a large amount. It seems reasonable to suppose that more than one-third of the volume of the natural tidal prism has been destroyed. If this is the case, the scouring value of the present prism is not much more than half the value of the natural prism. This completely upsets the natural "balances of forces," and there would be required a large reduction in the capacity of the channel of the harbor to restore that "balance."

But such a reduction could not be submitted to; on the contrary, the capacity of the channel has been steadily increased by artificial means, and I estimate the prospective sectional area from work now contemplated will be about 145 per cent. of its natural effective area. This enlargement of area will reduce the scouring efficiency of whatever volume of water flows through it more than one-half, and still further destroys the "balance of forces" of the natural condition.

The adoption of this enlarged channel marked the abandonment of the aid of the tidal basins. The work required to keep the larger channel free from deposits — provided the tide carries materials which the former currents just transported — is entirely beyond the capacity of the tidal basins to perform, and their value for such purpose is abolished. The channels, if there are deposits, must be maintained by the means used to enlarge them.

Fortunately, it is found in Boston harbor that enlarged channels are permanent. The marked depressions in the profile representing the bottom of the thread of the channel — depressions which appear in all the records of soundings which I have examined from 1775 to the present time — show that there is no regular process of deposit in operation in the harbor, like the rolling of grains of sand along the bottom, or similar causes of shoaling. Upon this profile some of the differences of different years are only to be accounted for by errors of measure-

ment; some by failure of the different parties to take soundings in the same places. The holes seem to prove that no rolling sand or other material is carried along the bottom of the channel. Some of the shallow bars have been dredged away.

The report of Lieutenant-Colonel Gillespie, Corps of Engineers, U. S. A., for the year 1888, states that: —

"The improvements by dredging both in the inner and outer harbor have been remarkably well maintained, and show no essential deterioration, with the exception of the dredging done at the western end of Great Brewster Spit or the eastern entrance of the 'Narrows.' Here, as shown by the latest surveys, the condition of the entrance is almost exactly what it was previous to the dredging."

The effort to make the tidal prism do our dredging does not seem to be so necessary now as it was forty years ago, when the United States Commissioners were studying the problem of maintaining the channels of Boston harbor.

Dredgers formerly had a bucket capacity of from 1 to 2 cubic yards, and a day's work may be said to be about 300 or 400 cubic yards in 10 hours; now the largest bucket dredgers have a capacity of 10 cubic yards for each filling of the bucket, with the prospect of larger dredgers to be made. One bucket dredge of the larger class, of which I have a brief record, had a bucket capacity of 8¼ cubic yards, or about 12 tons, and made a full revolution, with a load from water 25 feet deep, every 40 seconds; and a day's work of 10 hours amounted to 5,000 to 6,000 cubic yards. The rate of 1 bucket in 40 seconds, which was guaranteed by the builders, would amount to 7,425 cubic yards in 10 hours. A record of a 10 yard clam-shell bucket states that the bucket often comes up with fully 15 yards of material, and the machine handles easily 1 bucket per minute in 65 feet of water, without undue strain on any part of the machine. The dredge removed 4,000 or 4,400 yards per day, although capable of doing more. Scows holding 400 cubic yards each are often loaded in 30 or 40 minutes.

The contract for dredging through the upper middle to a depth of 23 feet in Boston harbor by the United States government in 1871 was awarded at 57 cents per cubic yard. In 1897 the contract was awarded by the United States government for dredging from the main ship channel in Boston harbor at 17¼ cents per cubic yard, to a depth of 27 feet.

The above figures of capacity and cost are based upon the removal of hard material of original formation from the bottom of deep channels. For the removal of all deposits of silt or other water-borne material from the rivers the pump dredge would be entirely suitable, and the cost to remove such material is much less than above given. The cost on the Mississippi River for large quantities to depths of 9 to 15 feet has been from 2 to 3.6 cents per cubic yard. It is only for the removal of such material that a charge could possibly be fairly made against the proposed improvement of Charles River.

Upon a review of the whole question of the effect of the dam upon the harbor, and taking into account all the conditions and circumstances, I believe that the erection and maintenance of the dam will be beneficial in a moderate degree.

Pollution of Charles River due to Overflow.

1. The Boston main drainage system was designed to remove a quantity of storm water equal to one-quarter of an inch depth per twenty-four hours (page 24, State Board of Health, upon "Discharge of Sewage into Boston Harbor").

On the assumption that one-half the rainfall reaches the sewer, this will care for all storms of one-half inch rainfall.

The Providence records of rainfall show storms exceeding one-half inch in depth during twenty-one years, 1881 to 1901 inclusive. Average for each month as follows: —

Table of Storms.

MONTH.	Average Number of Storms exceeding One-half Inch Depth in Twenty-four Hours.	Average Depth of the Storms (Each) in Excess of One-half Inch per Twenty-four Hours.	Average Duration of Storms (Each), in Hours.
January,	4.67	.655	18.58
February,	4.38	.669	19.59
March,	4.29	.573	22.57
April,	3.52	.455	20.22
May,	4.81	.457	17.00
June,	3.76	.423	11.85
July,	5.19	.480	8.35
August,	4.67	.514	11.20
September,	3.95	.673	12.31
October,	3.33	.691	17.38
November,	3.57	.681	20.64
December,	4.29	.581	16.85

2. The areas sewered by the combined system which overflows into the Charles River are: —

	Square Miles.
Part of Boston (estimated),	2.54
Part of Brookline (page 72 of the twelfth report of the Metropolitan Board),	2.92
Part of Brighton (page 72 of the twelfth report of the Metropolitan Board),	3.09
Part of Newton (page 72 of the twelfth report of the Metropolitan Board),	6.05
Part of Cambridge (page 70 of the same report),	4.91
Total,	19.51

3. The rainfall on this area of 19.51 square miles for the depths and times given in the "Table of Storms," above, and the amounts reaching the sewers on the basis of percentage collected in the stream on the Sudbury River, would be as follows: —

Table of Yield of Sewers in the Area sewered by the Combined System.

MONTH.	Cubic Feet per Second on 19.51 Square Miles due to the Storms. Excess of One-half Inch in Twenty-four Hours.	Per Cent. collected on the Sudbury, 1875-1900.	Cubic Feet per Second overflowed from the Sewers, from Storms.
January,	444.06	50.621	224.79
February,	429.91	71.351	306.74
March,	319.93	116.674	373.28
April,	282.97	106.863	302.39
May,	388.82	57.923	196.26
June,	449.45	27.645	124.25
July,	733.36	9.059	65.53
August,	577.65	12.910	74.57
September,	688.54	12.652	86.49
October,	500.31	21.425	107.19
November,	415.29	38.056	158.05
December,	409.27	52.451	214.67

4. The population, amount of sewage and corresponding areas for which the intercepting sewers are designed for the Charles River valley, as stated on pages 70 and 72 of the twelfth annual report of the Metropolitan Sewerage Commission, and page 68 of Senate Document No. 2, 1889, are as follows: —

MONTH.	Ultimate Area in Square Miles to contribute Sewage.	Population estimated for 1930.	Cubic Feet per Second Sewage and Water in 1930.
Cambridge,	6.11	126,000	51.00
Part of Boston,	1.61	34,000	11.70
Brighton,	4.27	18,000	6.30
Brookline,	6.81	16,800	5.80
Newton,	18.03	44,800	15.60
Watertown,	4.04	11,200	3.90
Waltham,	13.68	33,000	11.50
Totals,	54.50	283,800	105.80

Two hundred and eighty-three thousand, eight hundred people on 54.50 square miles averages 5,207 people per square mile; 105.80 cubic feet per second is equivalent to 1.941 cubic feet per second per square mile on 54.50 square miles of territory; or 105.80 cubic feet per second is equivalent to .373 cubic feet per second per 1,000 people.

5. Assuming an average population on the 19.51 square miles having the combined system of sewers, the total population will be 5,207 times 19.51, or 101,589.

The standard of water-carried polluted matter discharged as sewage is taken at 30 gallons per capita per day. This equals 4.6417 cubic feet per second for 100,000 people, or 4.7154 cubic feet per second for 101,589 people. The intercepting sewers are designed for 300 gallons per capita per day, to include sewage and water equivalent to one-fourth of an inch depth on the drainage area. Therefore, when the sewers begin to overflow, the sewage is diluted ten times; and the amount of polluting matter escaping with the overflow is one-tenth of 30 gallons per capita per day, or 3 gallons, equal to .47154 cubic feet per second for 101,589 people.

The sewage and storm water are mingled in the sewers, then, in such manner that the quarter-inch run-off, representing one-half inch rainfall, produces ten dilutions all the time during run-off of this amount. To this run-off is added the run-off due to the excess of one-half inch depth of rain. The average dilutions, then, at the overflows are as follows: —

$$\frac{\text{Overflow, c. f. s.}}{\frac{1}{4}\text{ inch on drainage area, c. f. s.}} \times 10; \quad \text{example, } \frac{224.79 \times 10}{131.15} = 17.14.$$

MONTH.	Dilutions due to One-half Inch Rainfall.	Dilutions due to Excess of One-half Inch Rainfall.	Sum.
January,	10	17.14	27.14
February,	10	23.33	33.33
March,	10	28.46	38.46
April,	10	23.06	33.06
May,	10	14.96	24.96
June,	10	9.47	19.47
July,	10	5.00	15.00
August,	10	5.69	15.69
September,	10	6.60	16.60
October,	10	8.17	18.17
November,	10	12.05	22.05
December,	10	16.37	26.37

The standard polluting matter which escapes through the sewers or at the overflow is 30 gallons per capita per day, or 4.7154 cubic feet per second; divided by each of the dilutions in the above column of sums, is as follows: —

Example, 4.7154 ÷ 27.14 = .17375.

MONTH.	Cubic Feet per Second Polluting Matter which overflows.	MONTH.	Cubic Feet per Second Polluting Matter which overflows.
January, ...	.17375	July, ...	.31436
February, . . .	.14148	August, . . .	.30054
March, ...	.12261	September, . . .	.28406
April, ...	.14263	October, . . .	.25952
May, ...	.18892	November, . . .	.21365
June, ...	.24219	December, . . .	.17832

The quantities given in the above column of cubic feet per second polluting matter which overflows represent the average of the polluting matter which will go into the Charles River. Dividing the flow of the river in cubic feet per second by these quantities, the results are given in the table below.

Example, 687.90 ÷ .17375 = 3,959.21.

The drainage area of Charles River to Mother Brook is 197.163 square miles. Of the flow from this area, Mother Brook is entitled to one-third.

	Square Miles.
The area yielding flow to Charles River is	131.442
The area from Mother Brook to Watertown is	75.585
The area below Watertown is	34.340
Total contributing area, ...	241.367

Flow and Dilution.

MONTH.	Cubic Feet per Second per Square Mile.	Flow in Cubic Feet per Second, 241.367 Square Miles.	Number of Dilutions if there were Continual Overflow into the River.
January, ...	2.850	687.90	3,959.21
February, ...	3.675	887.02	6,269.70
March, ...	4.988	1,203.94	9,819.51
April, ...	2.235	539.46	3,782.11
May, ...	1.775	428.42	2,267.76
June, ...	.920	222.06	916.87
July, ...	.350	84.48	268.73
August, ...	.475	114.65	381.48
September, ...	.605	146.03	514.06
October, ...	.750	181.03	697.54
November, ...	1.130	272.74	1,275.38
December, ...	1.410	340.33	1,903.20

The overflow is not continuous, but intermittent. The number of hours in each month, number of hours of overflow and the fraction of the month during which overflow takes place, are as follows: —

Example, 4.67 × 18.58 = 86.76 ÷ 744 = .11661.

MONTH.	Hours in Month.	Hours of Storm.	Fraction of Month in which Overflow occurs.
January,	744	86.76	.11661
February,	678	85.81	.12656
March,	744	96.81	.13012
April,	720	71.19	.09887
May,	744	81.75	.10988
June,	720	44.54	.06186
July,	744	43.34	.05825
August,	744	52.81	.07080
September,	720	48.64	.06756
October,	744	57.88	.07780
November,	720	73.67	.10232
December,	744	70.14	.09427

The number of dilutions due to a continual overflow, stated in the table next preceding the above, divided by this fraction of the month in which overflow takes place, is as follows: —

Example, 3,959.21 ÷ .11661 = 33,952.

MONTH.	Actual Number of Dilutions.	MONTH.	Actual Number of Dilutions.
January,	33,952	July,	4,613
February,	49,538	August,	5,426
March,	75,465	September,	7,610
April,	38,251	October,	8,966
May,	20,639	November,	12,465
June,	14,822	December,	20,188

The number of dilutions required to render the river water unobjectionable is 100. The sewage will, therefore, in the month of least dilution, be diluted more than is necessary 46 times over.

In the above calculations I have made no separate account of the 1,000 people in Boston whose drains now discharge directly into Charles River. The estimates are based upon the population which may, by overflow, discharge their drainage into Charles River in 1930; and I assume that before that time the ordinary sewage, at least, of this population will be discharged into the established sewerage system connected with the intercepting sewers, and that only the overflow of their sewage will go into Charles River. That portion of their sewage is taken into account in the calculations.

In case this 1,000 of the population continues to discharge its sewage direct into the river, about 5 feet per second of the ordinary river flow will be required to render that sewage unobjectionable in the basin.

I understand that this particular group of people spends its summers elsewhere, and no drainage of any account would be discharged during the time when offence might be feared.

In relation to the effect of holding the surface of the Charles at a constant elevation of 8 upon the ground water of the Back Bay section, my examination of the matter and my knowledge of the character of the mill dam leads me to the belief that the height of the river water has no appreciable influence upon the height of the ground water south of Beacon Street; that is affected by the rainfall, the evaporation and the sewers.

I conclude, therefore, that beyond doubt the sanitary condition of the

Charles River, if improved by maintaining a dam as proposed, will be entirely satisfactory, and that the level of the ground water in the Back Bay district will not be affected.

Quality of Water in the Charles River Basin under Tidal Flow.

A careful analysis of the drift of the tide at each hour of the flood and the ebb at the seven Coast Survey stations most nearly representing the conditions of flow in the inner harbor of Boston shows an almost exactly balanced average force of the ebb and flood. The small percentage of fresh water from the rivers seems to furnish the only resultant outward force. This being the case, it is evident that the tidal flow of the Charles River basin does for many days at all periods of the year consist of nearly the same water, alternately running out and in, but slowly making its way to the sea. A given measure of water from the middle of the basin will not in a single ebb reach Castle Island, and it will come back to nearly its former position on the next flood. While pulsating back and forth in the harbor, this volume of water is picking up such impurities as come to it, and it takes nearly the temperature of the surrounding land and air. There is no possibility of fresh and cool sea water coming into this basin in any considerable volume in a single tide. The change of water will as a whole come only by the gradual pushing out of the tidal prism by the fresh water coming down the river. That this is the case was illustrated before the Boston main drainage was established, by the lingering in the harbor of the discharge from the sewers along the shore. The volume of water flowing in Charles River varies greatly month by month through the year, and therefore the rate of complete renewal of the water in the basin varies greatly.

The entire volume of water which would be contained in the basin above the proposed dam, and from the bottom of the basin to elevation 8, is estimated at 382,000,000 cubic feet. This quantity of water would, on an average of years, be yielded by Charles River, and thus tend to a complete renewal of the water contained in the basin at the rate of furnishing the whole volume—

In 6.43 days for the January flow.
In 4.94 days for the February flow.
In 3.67 days for the March flow.
In 8.20 days for the April flow.
In 10.32 days for the May flow.
In 19.91 days for the June flow.
In 52.34 days for the July flow.
In 38.56 days for the August flow.
In 30.28 days for the September flow.
In 24.43 days for the October flow.
In 16.21 days for the November flow.
In 12.99 days for the December flow.

It is obvious that under these conditions the temperature of the water in the basin cannot be much affected by the sea water, and for purity reliance must be placed upon the river water.

Freshet Flow of Charles River.

The highest freshet known was in February, 1886. Rain began 7.45 A.M., February 11 and ended 2.45 P.M., February 13.

The average February flow of the stream at Waltham and through Mother Brook may be taken to be about 910 cubic feet per second, from the area of 248.1 square miles.

Mr. F. P. Stearns estimated, from the Waltham records and other means of information, the amount of water passing Waltham during the freshet, and also estimated the flow through Mother Brook. He found the amounts to be as follows: —

DATE.	TOTAL FLOW, CHARLES RIVER.		
	At Waltham (Cubic Feet per Second).	Through Mother Brook (Cubic Feet per Second).	Total (Cubic Feet per Second).
Friday, February 12, . . .	1,216	223	1,439
Saturday, February 13, . . .	4,365	802	5,167
Sunday, February 14, . . .	4,900	900	5,800
Monday, February 15, . . .	4,900	900	5,800
Tuesday, February 16, . . .	4,900	900	5,800
Wednesday, February 17, . .	4,900	900	5,800
Thursday, February 18, . . .	4,476	822	5,298
Totals, ...	29,657	5,447	35,104

I make the drainage area of Charles River to Mother Brook 197.163 square miles. Two-thirds of this area is supposed to supply the Charles and one-third to supply Mother Brook.

	Square Miles.
$197.163 \times \frac{2}{3} =$	131.442
Mother Brook to Watertown, ...	75.585
Below Watertown, ...	34.340
Total contributing area to the basin, ...	241.367

Mr. Stearns called the total area above Waltham, including the area contributing to Mother Brook, 248.1 square miles; and he found the maximum flood yield to be 5,800 cubic feet per second, or 23.37 cubic feet per second per square mile. At this rate the area below Waltham would yield 1,379 cubic feet, which, added to the maximum flow found at Waltham of 4,900 cubic feet per second, equals 6,279 cubic feet per second. But the largest yield to the river below Waltham had gone out to sea before the largest yield above Waltham had arrived. The heaviest supply of rain and snow was on the 12th of February, and the highest flow at Waltham was between the 15th and 16th of the month. I think we shall allow an ample quantity if we assume a flood discharge into the Charles River basin at the rate of 6,000 cubic feet per second.

Assume that at the period of maximum freshet flow in the river the highest known tide in Boston harbor should be repeated. In the tide which occurred when the Minot's Ledge lighthouse was carried away, in 1851, the tide water rose 5 feet and 7 inches above mean high water, or to elevation 15.58. If the surface of the basin is at elevation 8 when the tide below the dam reaches that elevation, then all discharge from the basin will be cut off while the tide is rising from elevation 8 to its highest level, and then recedes to an elevation at which the discharge of water from the basin can be resumed. Judging from the curves of the highest tides of which I have measurements, I think the time which would elapse from the time the tide reaches elevation 8 to reaching its highest level would be from two and one-half to two and three-quarters hours, and about the same length of time would be required for the tide to recede to elevation 8. I will call the time which will elapse for the whole period of rise and fall to elevation 8 six hours.

I make the area of the basin at elevation 10 to be 833 acres, or 36,285,400 square feet. This would represent the mean area if a rise of 4 feet should occur without overflowing the banks. Upon this area a yield of 6,000 cubic feet per second during six hours would be stored in causing a rise of the surface of 3.57 feet.

$$\frac{6000 \times 6 \times 3600}{43560 \times 833} = 3.57 \text{ feet depth.}$$

The water in the basin might be drawn down so as to make room to receive this freshet flow.

The amount of water which could be discharged through a lock 40 feet wide, with an effective depth equal to 10 feet below low water, having an elevation at grade 8 in the basin and a fall of 2 feet through the lock would be approximately as follows: area of discharging section at the lower end of the lock, $40 \times 16 = 640$ square feet; the theoretical velocity for 2 feet fall is about 11.35 feet per second; then $640 \times 11.35 \times .8 = 5{,}811.2$ feet per second.

Assume that the basin falls 4 feet and the tide falls sufficiently, then the sectional area of discharge at the lower end of the lock would be $40 \times 12 = 480$ square feet, and the discharge would be approximately $480 \times 11.35 \times .8 = 4{,}358.4$ feet per second. A mean of these two quantities is 5,084.8 feet per second.

Assume the mean area of the basin at elevation 6 to be 33,741,581 square feet, then the discharge of 5,084.8 cubic feet per second of stored water would lower the surface of the basin 1.84 feet in an hour, and the 4 feet would be drawn off in about two hours and ten minutes, and the tide outside would fall from 6 to 2 at nearly the same rate.

Discharging Capacity of Sluice Gates.

The estimated contents of the basin between elevation 8 and 2 is 182,670,600 cubic feet. If this is discharged through the sluice gate openings at an effective area averaging $14 \times 100 = 1{,}400$ square feet, at a mean velocity of 11 feet per second, then the contents of the basin will be discharged in

$$\frac{182670600}{1400 \times 11} = 11{,}862 \text{ seconds}$$

which number, reduced, amounts to 3 h. 17 m. 42 s.

It is assumed that this discharge through the sluice gate openings will occur under a constant head, or difference of level of the water above and below the gates, of 2 feet. The velocity due to this head is 11.342 feet per second. The mean velocity through a channel of moderate length having a uniform sectional area might be perhaps in the neighborhood of .8 the velocity due to the head; but with a converging entrance to the smallest section of discharging area and a diverging exit from the smallest section, this loss will be much diminished or even obliterated. Mr. Francis found that, under the most favorable form for the entrance to and the exit from the smallest section of a Venturi tube, he obtained a mean velocity of more than 2.4 times the velocity due to the head. In this case I think it is well on the safe side to assume a mean velocity nearly equal to that due to the head, and I have therefore estimated it to be 11 feet per second.

Estimated Cost of Sluiceways and Gates.

Iron and steel, 383,302 pounds, at 6 cents, ...	$22,998 12
Concrete, 8,425 cubic yards, at $6, ...	50,550 00
Asphalt pavement, 243 square yards, at $1.75, . .	425 25
Sidewalk surface, 162 square yards, at 60 cents, . .	97 20
Cribwork, say 2,700 cubic yards, at $5, ...	13,500 00
Fill under masonary, say 4,098 cubic yards, at 50 cents,	2,049 00
Motor and connections, ...	300 00
Housing for motor, ...	50 00
Stop planks, two sets, 12,144 feet B.M., at $25 per M.,	303 60
Excavation for bottom of cribs, ...	150 00
	$90,423 17
Ten per cent., ...	9,042 32
	$99,465 49
Say coffer-dam, ...	64,000 00
Total, ...	$163,500 00

These tidal sluice gates can, in my opinion, be operated freely at all times when the level of the water above and below approaches the same elevation, and they will work satisfactorily.

The gates are not, I believe, important or even useful on account of the harbor, but they are desirable for other uses.

Propositions.

The comparative insignificance of the volume of the river flow, it being less than 1 per cent. of the volume of one tide.

The mean forces of the flood and the ebb tide are almost equal to each other.

The conditions are such that the run of the ebb tide from Charles River, for about the last 2 feet of vertical height, tends to affect injuriously the channels of the harbor.

The source of material tending to form deposits in the harbor is mainly from the outer islands and from the flats and shores on the margin of the estuary. The chief source was formerly from the islands which have now been almost completely protected from the action of the sea.

As a whole, the harbor has not shoaled, but injurious shifting of the positions of deposits has occurred.

The great artificial changes in and about the harbor have transformed it from a natural basin, to be kept clear by natural forces, to an artificial basin, which must be kept open by artificial means. This change has abolished the value of the interior tidal basins.

The dilution of the sewage, necessarily discharged into the basin, by the natural flow of Charles River, is far in excess of that required for satisfactory sanitary conditions.

The quality of the water in the basin will be much better above a dam than under tidal flow, as at present.

A maximum freshet flow occurring at a time of maximum tidal flood will raise the water less in the basin with a dam than without one.

With the proposed sluice gates, the basin can be emptied in a single ebb tide.

The sluice gates are not needed for the harbor, but will be useful for other purposes.

STATEMENT OF PROF. W. M. DAVIS IN REFERENCE TO BOSTON HARBOR.

CAMBRIDGE, MASS., April 5, 1902.

Hon. NATHAN MATTHEWS, Jr., *Boston*.

DEAR SIR: — In accordance with your request, I have pleasure in sending you the following statement regarding the matter on which I recently spoke to you.

The original outline and depth of Boston harbor were due to the occupation by the sea of the surface of rock and drift left here at the close of the glacial period. This surface had a considerable inequality. Changes in the level of the land with respect to the sea accompanied the close of the glacial period. When the present level was assumed, the outline and depth of the harbor — the "original form of the harbor" — were due simply to the occupation by an arm of the sea of the basins and troughs that then stood beneath sea level in this district. Since that time significant changes have been produced by the action of the waves (chiefly on the outer, exposed coast) and by the tides. Several islands have been completely washed away, others have been much consumed. The sand and mud from these consumed islands has been distributed in beaches, as in Nantasket beach (chiefly derived from "lost islands," more to seaward), in bottom sediments and in tidal marshes, the latter in the more protected interior water bodies. While the tidal currents have frequently acted to prevent or at least to retard the narrowing of channels by growing spits and beaches, and while they have in some cases acted to scour channels to more than their original depths, the greater action of the tides, especially in the inner harbor, has, I believe, been constructive. The outer shore line has lost under the combined action of waves and tides, the waves being the stronger of the two agencies; the inner shore line has frequently gained. It is highly probable that changes of similarly contrasted kinds have occurred on the bottom; but before expressing definite opinion on this point, with special reference to particular localities, I should wish to see the records of boring and soundings.

Very truly yours,

W. M. DAVIS.

CAMBRIDGE, MASS., April 10, 1902.

Hon. NATHAN MATTHEWS, Jr., *Boston*.

DEAR SIR: — Allow me to supplement my letter of the 5th with the following statement regarding the harbor channels.

In the second report, United States Harbor Commissioners, 1860, page 49, it is stated that "the main channel of the upper harbor of Boston . . . is but the trench dug through the yielding bed of the harbor by the passage to and fro of the river and tidal waters."

I wish to point out that this explanation of the origin of the harbor channels, adopted more or less completely by later writers, does not represent the present science of geology, however appropriate it may have been to the science of forty years ago. At that time the glacial theory, then announced, but by no means established and elaborated as it is to-day, received no adequate consideration in explanation of the harbor topography. Moreover, the general study of land forms had

then hardly begun the great advance that it has made in the last forty years. Geologists to-day recognize many other causes for harbor channels than tidal action alone. While it may be difficult to give a precise statement of the manner in which any particular part of the harbor and its channels originated, it may be stated with confidence that the United States Commissioners were wrong in asserting that the channel of the upper harbor was simply a trench dug out by the passage of river and tidal waters. There is no evidence to prove that the channel was ever filled.

Since the formation of the original harbor (after the disappearance of the glacial sheet, and on the assumption of the present altitude of the land with respect to the sea) the action of waves and tides and streams have been both constructive and destructive. Destructive action of streams has been on the lands above the sea level, and with this we are little concerned; destructive action of the sea has been chiefly on the outer and more exposed shores. Constructive action of the sea is seen in the formation of extensive beaches of gravel and sand in association with the exposed outer shore lines, and again in the formation of extensive tide marshes, composed in large part of the fine silt brought by the flood tide from the outer shore (organic materials also have contributed to the formation of these marshes, land streams have done relatively little). Between the exposed outer shores and the protected inner marshes the play of the tidal currents has been partly destructive, partly constructive. As for the upper channel, the configuration of the shores and of the bottom, the formation of marshes in neighboring waters and the character of bottom deposits as revealed in numerous borings, go far towards proving that the United States Commissioners were wrong, and that the upper harbor channel has not been dug out, but has been somewhat filled by the sediments that the tidal currents have brought there. The difficulty in making a decided statement in this matter lies largely in the untechnical or ungeological nomenclature of the materials found in the harbor borings.

Very truly yours,

W. M. DAVIS.

HEALTH DEPARTMENT, CITY OF BOSTON.

HEALTH DEPARTMENT, OLD COURT HOUSE,
BOSTON, May 26, 1902.

HENRY S. PRITCHETT, Esq., *Chairman of Committee.*

DEAR SIR:—The Board of Health has received your letter, in which you ask its opinion as to what effect the proposed dam at Craigie bridge in Charles River would have on the health of the city. In reply, the Board will say that there is to-day in Charles River, between Craigie and Essex Street bridges, a decided and well-recognized public nuisance. The foul odors from this river bed and its shallow waters are not confined within narrow limits, but are frequently conveyed to considerable distances from the river. The incidental causes, such as old and fresh deposits of sewage, and the inherent conditions of filth in a river bordered by a dense population, make its muddy bed, its shallow places and its borders constant sources of pollution and damage to an otherwise

healthy atmosphere. The Board understands that the dam will keep the whole of the river bed deeply covered with water, and is to be provided with sluices by which the whole waters of the basin may be released at one tide. It also understands that the present inflow of sewage from the Beacon Street houses will be diverted elsewhere, as a part of the scheme. With this understanding, the Board of Health unhesitatingly advises that the erection and maintenance of the proposed dam will increase the health, comfort and pleasure of the citizens of Boston.

Respectfully,

SAMUEL H. DURGIN,
Chairman.

METROPOLITAN WATER AND SEWERAGE BOARD.—ENGINEERING DEPARTMENT,—SEWERAGE WORKS.

PEMBERTON BUILDING, BOSTON, May 8, 1902.

JOSEPH W. LUND, Esq., *Secretary, Committee on Charles River Dam, 14 Beacon Street, Boston, Mass.*

DEAR SIR:—In amended reply to your verbal inquiry of March 28 at this office, and referring to Mr. William S. Youngman's letter of April 29, addressed to Henry S. Pritchett, Esq., chairman of your committee, I may state that a continuous automatic record of the flow in the Charles River valley metropolitan sewer is maintained in Huntington Avenue, at a point about 600 feet above the junction of the sewer with the Boston main drainage system at Gainsborough Street. I enclose a copy of a table giving data deduced from this record. It shows the periods during which the depth of flow in the sewer was sufficient to close the regulating valves on the local connections, during the last four years, to have been as follows, expressed in percentages of a whole year:—

1897-1898.	1898-1899.	1899-1900.	1900-1901.
Per Cent. 33	Per Cent. 26	Per Cent. 13	Per Cent. 19

It will be seen that the earlier years show a larger period of shut-off, due to the relatively lower efficiency of the engines and pumps, at the city pumping station, as compared with that now existing.

The figures given do not necessarily imply that the metropolitan sewer was overflowing into the Charles River for the periods represented by these percentages. A volume equal to the capacity of the sewer, as governed by the depth of flow at any given time, was probably being delivered to the pumping station. And in the higher districts, where tidal conditions do not influence the connections of sewers on the separate system, and in which the volume of sewage even during storms, is comparatively small, much of the sewage was doubtless accommodated by the metropolitan sewer. There are no exact data

referring to this point, but it seems likely that the percentages expressed in the table may apply to the Back Bay district of Boston, Brookline and Brighton, involving the following overflows: —

Near Faneuil Station.
Parsons and North Beacon streets.
North Beacon Street.
Western Avenue and Everett Street.
North Harvard and Spurr streets.
Rena and Bertram streets.
Cambridge and Seattle streets.
Salt Creek.
Beacon and St. Mary streets.
Brookline Avenue.
Vila Street.
Near Parker Street.
Bryant Street and Huntington Avenue.

The overflow from the Charles River metropolitan sewer at the intersection of Beacon and St. Mary streets discharges into the Charles River through a Brookline town sewer, 7 feet in diameter. At this point the 5-foot metropolitan sewer passes under the Brookline sewer in a depressed section. The invert of the Metropolitan sewer is 1.6 feet below mean low water, and the invert of the Brookline sewer is about 2 feet above mean low water. The two sewers are so arranged that the Brookline sewer cannot discharge into the metropolitan sewer through the overflow connection, but the metropolitan sewer, when running under head, overflows into the Brookline sewer. This condition implies a high degree of dilution, by storm water, in the metropolitan sewer.

The preceding statements apply to existing conditions, which will be modified by the operation of the high-level sewer now under construction. Pumping plant to be erected at Ward Street will lift the Charles River valley sewage into the new sewer, and this function will not be liable to interference or occasional interruption by causes affecting the operation of the Boston main drainage system, into which that sewage is now discharged. It is anticipated, therefore, that after the new sewer has come into operation the percentage of overflow on the south side of the river, above Gainsborough Street, will not exceed that on the north side, or about 3 per cent., as indicated by the later studies of the city engineer of Cambridge and the chief engineer of the State Board of Health. The work now in progress for increasing the pumping capacity of the Calf Pasture station of the Boston main drainage system should have the effect of materially reducing the overflows from the collecting systems of the Back Bay district of the city of Boston.

Yours respectfully,

WM. M. BROWN,
Engineer, Sewerage Works.

Table showing Periods during which the Depth of Flow in the Charles River Trunk Sewer of the Metropolitan System was sufficient to close the Regulating Valves on the Local Connections, as deduced from Automatic Recording Gauge, near the End of the Charles River System, from 1897 to 1901, inclusive.

MONTH.	Number of Days Flow was above Point of Regulation Some Part of Day.				Equivalent Length of Time, in Days.				Longest Continuous Period in Each Month in Days.				Longest Period of Consecutive Days during which Regulators were Closed Some Portion of Each Day.			
	1897-1898.	1898-1899.	1899-1900.	1900-1901.	1897-1898.	1898-1899.	1899-1900.	1900-1901.	1897-1898.	1898-1899.	1899-1900.	1900-1901.	1897-1898.	1898-1899.	1899-1900.	1900-1901.
December, . .	14	25	3	16	8.75	14.51	.64	10.21	5.4	2.69	.34	5.67	12	15	-	9
January, . .	17	25	19	7	11.00	11.72	8.91	3.88	4.6	2.47	4.20	1.20	9	9	9	3
February, . .	24	13	16	2	16.00	5.72	11.57	.33	7.3	1.05	6.59	.33	16	2	7	2
March, . .	16	27	9	11	8.25	17.56	5.63	4.13	4.7	5.23*	2.91	.50	8	20	6	2
April, . . .	22	28	3	19	11.00	19.42	.74	12.00	3.0	7.24	.35	2.83	10	13	-	10
May, . . .	24	8	12	23	18.50	6.06	6.01	17.13	11.9	5.40†	2.22	8.21‡	23	6	5	9‡
June, . . .	21	11	9	8	11.75	3.48	1.61	3.92	4.8	.92	.56	1.04	-	7	4	3
July, . . .	14	8	5	11	6.00	3.68	1.32	7.46	1.6	1.10	.77	1.46	4	3	2	8
August, . .	16	6	3	2	5.50	3.04	.75	1.17	1.2	1.27	.42	.63	6	3	3	-
September, .	3	5	4	8	1.00	1.92	1.41	2.04	.6	.71	.69	.79	-	2	3	5
October, . .	19	4	5	7	12.75	1.17	2.06	4.95	4.1	.51	1.05	2.52	7	2	3	4
November, . .	18	9	10	7	10.50	5.48	6.28	3.69	3.4	1.04	2.01	1.73	7	5	4	4
Totals, . .	208	169	98	121	121.00	93.76	46.93	70.91	-	-	-	-	-	-	-	-
Percentages of total days of year, ...					33	26	13	19	-	-	-	-	-	-	-	-

* Part in March and part in April. † Part in April and part in May. ‡ Part in May and part in June.

REPORT ON SAULT STE. MARIE LOCKS.

FEB. 18, 1902.

Mr. JOSEPH RIPLEY, *Assistant Engineer and General Superintendent, "Soo" Canal, Sault Ste. Marie, Mich.*

DEAR SIR: — I wish to obtain information concerning the dimensions, construction and operation of the ship canal under your charge, especially as to the type of lock, method of operating same, and the actual time required for the passage of vessels through the lock. If you will kindly give me the length, width and depth of locks, the type of gates, the method of filling and emptying and the difference of water level above and below the lock, and a statement as to the actual time required for the largest vessels which pass to go through the lock from the time of beginning of change of water level to the emergence of the vessel at the farther end of the lock, it will fully answer my purpose.

I am interested in the designing of a special lock for a special purpose near Boston, and such information as you may send me will be appreciated.

I do not readily find the information in the report of the Chief of Engineers, U. S. A.

Yours very truly,

PERCY M. BLAKE.

UNITED STATES ENGINEER OFFICE,
SAULT STE. MARIE, MICH., April 12, 1902.

Mr. PERCY M. BLAKE, *Newtonville, Mass.*

DEAR SIR: — Replying to your request of Feb. 18, 1902, for information relative to canal locks here, I enclose traffic statement for the years 1855–1900, also statistical report for the season of 1901.

The fall in St. Marys Rapids ranges from 16½ to 20½ feet. The first lock was built on the Canadian side of the river by the Hudson Bay Fur Company some time between 1796 and 1798. It was 38 feet long, 8 feet 9 inches wide, with a lift of 9 feet. A tow-path was made along the shore for oxen to pull the batteaux and canoes through the upper part of the rapids. This lock, excepting the timber floor and miter-sills, was destroyed in 1814 by United States troops from Mackinaw Island, under command of Major Holmes.

The second one was built on the American side of the river, in 1853 to 1855, and is known as the State canal, as the United States gave a grant of 750,000 acres of land in Michigan for construction thereof. The canal was $1\frac{1}{12}$ miles long, 64 feet wide at bottom, 100 feet at water surface and 13 feet deep. There were two tandem locks of masonry, each 350 by 70 feet by 11½ feet on the miter-sills, with a lift of about 9 feet each. Chas. T. Harvey was superintendent of construction, and the contractor was the St. Marys Falls Ship Canal Company. The locks were destroyed in 1888 while excavating the pit for the present Poe lock.

The Weitzel lock, 515 feet long, 80 feet wide in chamber, narrowing to 60 feet at the gates, with 17 feet of water on the miter-sills at mean stage, was built in the years 1872 to 1881, by the United States. The depth of water in canal was increased to 16 feet and the average width to 160 feet; the stone slope walls were replaced with timber piers having vertical face. Gen. Godfrey G. Weitzel was the engineer

officer in charge of the district from 1872 to 1882, and Alfred Noble, recently a member of the Isthmian canal and the deep water way commissions, was the assistant engineer in local charge, and designed the lock, with the filling and emptying valves and the operating machinery. Boyle & Roach were the principal contractors.

The Canadian canal, 1⅛ miles long, 150 feet wide and 22 feet deep, with lock 900 feet long, 60 feet wide, with 22 feet on the miter-sills, was built on north side of river, between the years 1888 and 1895. W. G. McNeill Thompson was the government engineer in local charge. Ryan & Haney were the contractors.

The Poe lock, 800 feet long, 100 feet wide and 22 feet of water on the sills, was built in the years 1887 to 1896, by the United States. Gen. O. M. Poe was the engineer officer in charge of the district, and E. S. Wheeler the assistant engineer in local charge. Hughes Bros. & Bangs were the principal contractors.

The American canal has been deepened to 25 feet, and the entrance piers extended, so that the total length is now 1⅝ miles. The width is variable, being 500 feet at the upper entrance, 108 feet at the movable dam, 270 feet at the basin above locks and 1,000 feet at the lower entrance. Dunbar & Sullivan were the principal contractors.

The channel through St. Marys River has been improved through shoals of sand, clay, boulders, sandstone rock and limestone rock to a least depth of 20 feet at mean stage of water and to a least width of 300 feet.

The approximate cost, in round numbers, of the several improvements, is as follows: —

Locks and canal of 1855, ...	$1,000,000
Weitzel lock, deepening and widening canal, ...	3,000,000
Poe lock, deepening and widening canal, ...	4,000,000
Improving channel through river, ...	3,000,000
Canadian lock, canal and approaches, ...	4,000,000

Hydraulic power is used for operating the Poe and Weitzel locks, a pressure of 115 pounds being used for the Weitzel lock and a pressure of 400 pounds per square inch being used to operate the Poe lock machinery. Electricity is used on the Canadian lock.

The Poe lock can be filled or emptied in about 7 minutes, and an up-lockage of a boat 350 feet long has been made in 11 minutes. The gates can be opened or closed in 2¼ minutes, but 3 to 5 minutes are usually taken.

Drawings and descriptive text of the Weitzel lock were published in 1885 by the United States Engineer Department. Drawings are being prepared to accompany descriptive history of the Poe lock.

For detailed statements for progress of work and cost of the Weitzel and Poe locks, see annual reports of the Chief of Engineers, United States Army, for the years 1871 to 1901.

All of the numerous newspaper and magazine articles on the locks have errors of statement, but among the best, mention can be made of those published in the "Engineering News" of New York; the "Miller" of Minneapolis, Minn., of Dec. 23 and 30, 1892; the Minneapolis "Journal," Sunday edition for Aug. 19, 1900; the "Marine Review" of Cleveland, O.; and the annual report of the superintendent and collector of the St. Marys Falls ship canal to Governor Croswell of Michigan, for the year 1878.

Three blue-prints are in separate package.

Very respectfully,

JOSEPH RIPLEY,

General Superintendent.

CHARLES RIVER BASIN. — LEGISLATION RELATING TO HARBOR LINES, DREDGING, SEA WALLS, RECLAMATION OF FLATS, ETC., PILING, BRIDGES, FILLING, TIDAL WATERS.

Acts of 1901.

Appointment of committee to consider advisability of constructing a dam across Charles River between Boston and Cambridge, ... Resolves, Chap. 105
Boston harbor: —
Change of harbor line at Jeffries Point in East Boston, . Chap. 419
Provision for additional mooring facilities and anchorage ground in Boston harbor, dredging, etc., ... Chap. 476
Harbor line of Cambridge changed, ... Chap. 245
Part of harbor line below Charlestown bridge changed, . Chap. 411
Bridge to be constructed over Mystic River between Somerville and Medford, ... Chap. 491

Acts of 1900.

Boston harbor: —
Provision for dredging, ... Chap. 309
Authority for East Boston Dry Dock Company to extend its marine railways beyond harbor line, ... Chap. 308
Relative to appropriation by Congress for the improvement of Boston harbor, ... Resolution, page 527
Relative to rebuilding Broadway bridge, ... Chap. 452
Acquisition of Fuller's wharf, Brighton district, . . Chap. 467
Protection of flow of water from Charles River into and through Mother Brook, etc., ... Chap. 161
Authority to investigate advisability of regulating flow and fluctuations of Charles River, ... Chap. 461
Cession to United States of jurisdiction over land near entrance to Navy Yard, ... Chap. 247
Relative to Malden bridge, ... Chap. 296
Authority for Metropolitan Park Commission to make rules and regulations to govern public use of Charles and other rivers, ... Chap. 340
Authority for Metropolitan Park Commission to improve the banks of Charles River, ... Chap. 465
Provision for an examination and report as to anchorage of vessels in Boston harbor, ... Resolves, Chap. 97

Acts of 1899.

Relative to Stony Brook, ... Chap. 397
Cession of land in Boston harbor to United States, . . Chap. 64
Authority to build bridge between Boston and Cambridge, Chap. 180
Relative to rebuilding Malden bridge across Mystic River, Chap. 280
Relative to improvement of Boston harbor, ... Chap. 469
Relative to drains and water courses in Waltham, . . Chap. 283
Provision for construction of high-level gravity sewer for relief of the Charles and Neponset River valleys, . Chap. 424

Acts of 1898.

Change of harbor lines and improvement of South Bay, . Chap. 278
Authority for Boston and Cambridge to construct and maintain bridge over Charles River, ... Chap. 467

Authority to construct dam across Charles River between Boston and Cambridge,	Chap. 531
Relative to Stony Brook,	Chap. 262

Acts of 1897.

Authority to rebuild Longwood Avenue bridge,	Chap. 162
Relative to Stony Brook,	Chap. 378
Relative to Charles River sewerage system,	Chap. 502
Relative to construction of a dry dock at Charlestown,	Resolution, page 629
Relative to drains and water courses in Waltham,	Chap. 152
Change of harbor line on northerly side of Charles River in front of Hoosac Tunnel docks,	Chap. 479
Relative to construction of approaches to new Charlestown bridge,	Chap. 346
Public ownership and control of East Boston lands and flats,	Chap. 486
Provision for construction of a pier and dock on South Boston flats,	Chap. 513
Relative to Dorchester Avenue bridge,	Chap. 512

Acts of 1896.

Relative to excavations, fillings and construction in tide waters, Boston,	Chap. 284
Authority to construct and maintain bridge over Charles River between Boston and Cambridge,	Chap. 315
Relative to Stony Brook,	Chap. 530
Relative to improvement of Boston harbor,	Resolution, page 653
Relative to appropriation for dredging Boston harbor,	Chap. 330
Relative to construction of sea wall along Charles River in Cambridge,	Chap. 508
Relative to settlement of certain controversies concerning flats in Charles River,	Resolves, Chap. 17
Provision for improvement of South Boston flats,	Chap. 442
Waltham may take land on Charles River,	Chap. 215

Acts of 1895.

Relative to the establishment of a new ferry landing in Boston (Fort Hill wharf),	Chap. 435
Provision for investigation for improved system of docks and wharves at Boston,	Chap. 291
Relative to bridges over Charles River,	Resolves, Chap. 110
Relative to settlement of certain controversies concerning flats in Charles River,	Resolves, Chap. 49
Relative to dry dock at Charlestown Navy Yard,	Resolution, page 704
Authority for Brookline Gas Light Company to lay its pipes to and across Fort Point channel,	Chap. 405
Provision for printing report of Joint Board upon Improvement of Charles River,	Resolves, Chap. 61
Relative to shoalings in Boston harbor since 1860,	Resolves, Chap. 74
Relative to report of Joint Board on Improvement of Charles River,	Resolves, Chap. 107

Acts of 1894.

Authority to build public highway bridge across Chelsea Creek between Chelsea and Boston,	Chap. 165
Authority for Boston to construct and maintain bridge across Charles River,	Chap. 217

Requiring Joint Board to submit plans for improvement of Charles River, ... Chap. 529
Relative to proposed construction of a dam and lock in Charles River basin, ... Resolves, Chap. 85
Relative to exclusion of tide water from certain marsh lands in Revere, Winthrop, etc., ... Chap. 311
Authority for Metropolitan Park Commission to make expenditures for open spaces along or near Charles River, ... Chap. 509
Relative to report of Joint Board on Improvement of Charles River, ... Resolves, Chap. 84

Acts of 1887.

Provision for union railroad passenger station between Charles River and Causeway Street, Boston, . Chaps. 302, 410

Acts of 1886.

Provision for union railroad passenger station between Charles River and Causeway Street, Boston, . . Chap. 292

REMARKS IN REGARD TO THE ALSTER BASIN AT HAMBURG.

By C. O. Gleim.

Hamburg, Nov. 28, 1894.

The Alster basin was originally a mill-pond, created by a dam in the line of the present Jungfernstieg, with an overflow and a water power at its eastern end, which existed since 1164. To this was added, in 1246, a second water power lower down the river at the Muhlen-Brucke (mill bridge) in the interior of the city, which, however, was very much inconvenienced by the rise and fall of the tides on its lower side, coming up from the Elbe, into which the Alster empties. The water level between the two dams being utilized for barge traffic, a navigable outlet was constructed at an intermediate point by Graskeller lock, while no navigation to the upper Alster basin was provided for. Another canal through the city, the Bleichen-Fleeth (originally a ditch of the mediæval fortification) was on the same level and in navigable connection with the intermediate part of the Alster, and was provided with flushing arrangements both for receiving water from the Alster basin and for letting water out to the Elbe.

This was the state of things that existed at the time of the great fire of 1842, which destroyed nearly the whole part of the city adjacent to the water courses between the two dams. In the plans for the reconstruction of the city, which were very comprehensive, it was decided to retain two dams with an intermediate basin; but the levels were somewhat changed, and the water power was concentrated in the upper dam, at the same time changing its location.

The works of the lower dam at Muhlen-Brucke and Graskeller lock not having been high enough to exclude exceptional tides from entering the intermediate basin as well as even the upper Alster basin, the streets in the line of the lower dam (the Grosse Burstah and connecting

streets) were raised several feet, now forming a high-water dyke across the valley of the Alster to the hilly parts on the sides, and thus protecting a large part of the city from overflow even in the case of exceptional tides. Also the intermediate level was at that time brought into navigable connection with the Alster basin.

Before giving any figures about the water levels, it may be well to premise a few words in regard to the datum to which water levels are referred in Hamburg. Any quotations in feet that may be found in older publications refer to the old city datum line, now abandoned, and the feet are in Hamburg measure, 1 Hamburg foot being equal to .28642 metres, or .9397 English feet. At the time when the metre system was introduced in Germany (after 1870) it was decided, in order, to adopt a new datum level 10 Hamburg feet lower than the old one; and to this all quotations of levels expressed in metres must be understood to refer.

The rise of the tide in the Elbe at Hamburg, which is about 80 miles from the sea, is very irregular, the variations being much more influenced by wind than the difference between neap and spring tides. The general average of tidal low water is 3.26 metres, that of high water 5.08 metres above zero, giving an average rise and fall of 1.82 metres, or very nearly 6 feet English. But under the influence of westerly winds and an accumulation of two successive tides the water rises occasionally to 7 or 8 metres, and has even reached the level of 8.74 metres, while the lowest ebb ever known was as low as 1.51 metres, giving an extreme range of tides of 7.23 metres, or 23 feet 9 inches. A tide coming up to the level of 6.30 metres is called a storm tide, and is announced to the inhabitants by cannon signals, when a telegram from Cuxhaven, the harbor at the mouth of the Elbe, brings notice of a corresponding stage of the tide there. This happens quite frequently, while a tide reaching above 7 metres is very rare.

The normal level of the Alster basin is fixed at 6.60 metres, or generally a little lower. The water may without detriment be drawn off to a level of 6.45 metres; with a level of 6.40 metres the passenger steamers would begin to touch bottom, and therefore it is not feasible to lower the water level so far, except in times when navigation is stopped by ice, in which case it is sometimes considered expedient to draw it off still further, in order to prepare for a rise in the river from an expected melting of snow and ice in the upper region. On the other hand, a rise above 6.70 is not permissible, because the steamers would not find sufficient head-room under some of the bridges, and at higher stages the water would enter into the cellars and overflow the landing stages of the steamers; at 7.10 metres the gates in the dam would be overflowed.

Thus it will be seen that the level of the Alster basin is kept within pretty narrow limits, in spite of rather scant provision for letting surplus water out through the upper dam. Telegraphic advice is given from the next lock, 6 miles above, of any freshet in the river, and the openings in the dam regulated accordingly.

The main outlet through the upper dam is under Schleusen-Bruecke about 150 metres (say 500 feet) south of the Jungfernstieg line. As originally built, this consisted of a lock 5.3 metres wide by 25 metres long, and on either side a system of flood gates 7.78 metres wide, with a clear opening of 11.16 square metres each. One of these side openings was in 1891 transformed into a lock 6.5 metres wide, of peculiar construction, offering a free outlet for flood water when it is not used for navigation. A special account of this structure is to be found in the "Deutsche Bauzeitung" of 1891, pages 405, 413, 417.

A second outlet through the upper dam was retained in the line of Bleichen-fleeth, and used as a water power. It is carried in a culvert under Jungfernstieg and the adjoining houses, in order to utilize the valuable frontage on that street, and empties through gates of about half the width of those on either side of the lock. The water power, formerly used for a flour mill, has gradually been abandoned, owing to the increasing claims made on the Alster water for lockage and flushing sewer system. At first an auxiliary steam plant was added, to serve in times of deficiency of water, and finally the turbine wheels were removed in 1887, the mill building being now used for an electrical central station, driven by steam, while the outlet for flood water has been retained.

On the whole, the outlets for flood water in the upper dam are not considered quite adequate, necessitating great care and watchfulness in the working of the flood gates, and sometimes giving rise to anxiety in times of freshets.

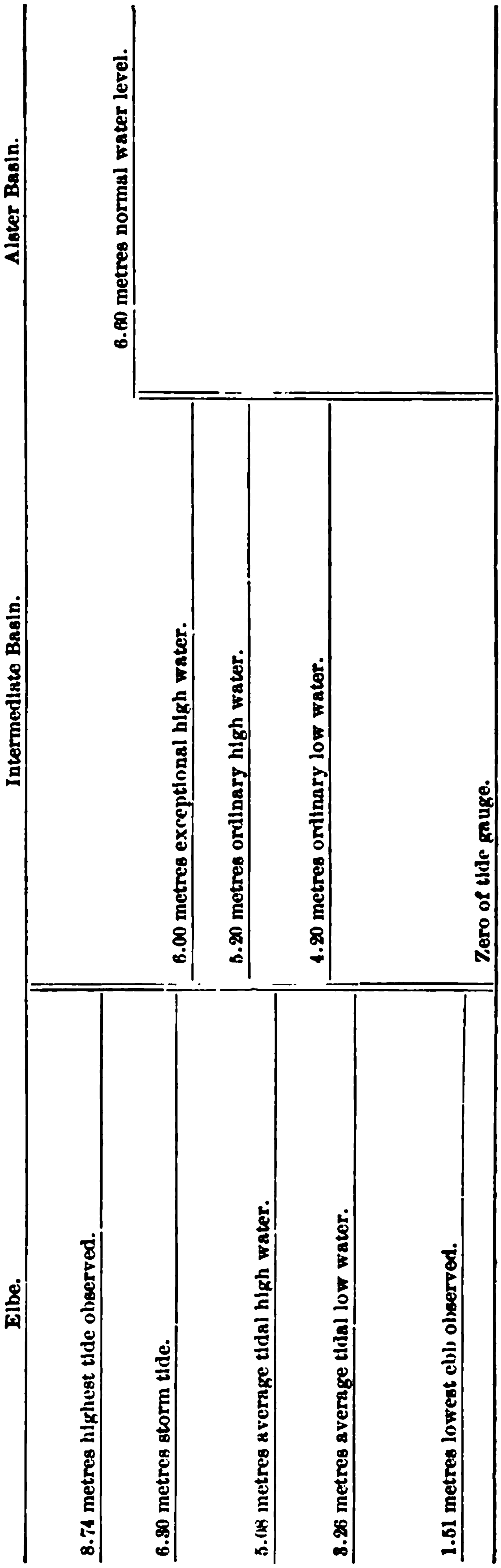
The water level in what is called the intermediate basin between the two dams is generally allowed to fluctuate with the tides between the levels of 4.2 metres and 5.2 metres on the tide gauge, the gates in the lower dam being open during the greater part of the tide, but closed when the water in the Elbe falls below 4.2 metres, or when the tide is expected to rise much above 5.1 metres.

The outlets from the intermediate basin to the Elbe consist of: (1) the old channel under Muhlen-Brucke, where no lock, but only a set of gates is provided; (2) the old Graskeller lock, which has been improved by the addition of storm gates as a safeguard against exceptional tides; (3) Michael's lock, in the line of Bleichen-fleeth, built in 1882. There are no flood gates at any of these points, the water being let out through the lock chambers.

It will be seen that the "Intermediate basin," while open to the tides and free communication with the Elbe, as far as practicable, serves the double purpose of retaining the water at low stages of the tide in the interest of navigation, and of excluding tides of more than average height, a stage of water above 6 metres on the tide gauge producing serious inconveniences to the cellars of adjoining houses. Sometimes the water is stored up to this level, the highest that is practicable, for the purpose of flushing the sewers at low ebb tide. On the other hand, during storm tides, when the outfalls of the sewers into the Elbe have to be closed, the intermediate basin is kept low and serves as a temporary reservoir for the discharge from the storm outlets of the sewers.

In the narrow canal connecting Bleichen-Fleeth with the main channel there is also a set of gates, allowing a difference of levels to be temporarily established between the two parts of the intermediate basin.

The following is a synopsis of the different water levels: —


Alster Basin.
6.60 metres normal water level.
Intermediate Basin.
6.00 metres exceptional high water.
5.20 metres ordinary high water.
4.20 metres ordinary low water.
Zero of tide gauge.
Elbe.
8.74 metres highest tide observed.
6.30 metres storm tide.
5.08 metres average tidal high water.
3.26 metres average tidal low water.
1.51 metres lowest ebb observed.

The three maps on a scale of 1 in 4,000 accompanying these remarks show the details of the location of the different works. The maps on a scale of 1 in 20,000, marked as "Exhibit A," show the various water courses around Hamburg in different colors. Besides the Elbe, the Alster basin and the intermediate basin, there will be found in separate colors the canal system of the Hammerbrook marsh and the Bille River, both of them separated from the Elbe by locks, the gates of which are open at low stages of the tide.

The Alster basin is separated into two parts by an embankment which is a remnant of the old fortifications, now used for a street and a railway, under which the water communication is maintained by a bridge called Lombards Brucke, with three arches of 17.09 and 17.38 metres in width. The inner Alster basin has a surface of 20.17 hectares, or 49.84 acres, the outer Alster inside the bridges crossing its branches 172.11 hectares, or 425.30 acres; the extreme length of both basins together being a little over 2 miles, with an extreme width of ¾ of a mile. But it will be noticed that these branches are of considerable extent. On the east side there is the Eilbeck canal, used for passenger steamers to its end, 1¼ miles from the Alster basin, with a prospect of being extended to the boundary of the Prussian city of Wandsbek. Also on the east side there is the Osterbeck canal, now ending at the gas works, for the coal transportation of which it is extensively used, also with a prospect of an extension to the suburb of Harmbeck. On the west side there is the Isbeck canal, leading to the suburb of Eimsbuttel, on which, owing to its roundabout course, there is no passenger traffic as yet. The upper Alster itself is used for passenger steamers for about 1 mile above the basin, up to the bridge connecting the villages of Eppendorf and Winterhude; but it is intended to extend the level of the Alster basin about 3 miles further up to Ohlsdorf, where the central cemetery of Hamburg is located, by digging a canal according to the lines marked in red on "Exhibit A," instead of the present shallow and crooked channel of the upper Alster. In connection with this work a new lock will have to be constructed at Ohlsdorf, to replace the present one, about 300 metres above the new location.

The upper Alster is a shallow stream coming from marshy regions in the Prussian Duchy of Holstein. On the accompanying map, marked "Exhibit B," the drainage area above the dam of the Alster basin is marked in red hatching. Its surface is 574 square kilometers, or 222 square miles.

"Exhibit C" is a longitudinal profile of the Alster from the lower dam in the city of Hamburg to its source, a length of about 30 miles, showing a succession of dams, by which navigation on a very primitive scale is kept up, principally for bringing peat, bricks and similar products to town.

As to the amount of water passing through the Alster basin at various times, there are no reliable figures to be had. The Alster basin is practically kept clear of house drainage by the very complete sewer system of Hamburg, which extends to the suburbs. There still exist a few cases of contamination at the extreme ends of the above-mentioned branch canals, the affluents coming partly from beyond the limits of Hamburg jurisdiction; but the offence is only temporary, and of a purely local character.

In spite of these infractions against the established policy, the basin proper, as well as the connecting canals, generally does not give rise to any complaints, but is a source of pleasure and usefulness to the community. There is considerable traffic, principally in coal, building

materials, etc., no less than 37,500 vessels having passed in one year through the main lock under Schleusen-Brucke before the second lock was added. There are comparatively few manufacturing establishments dependent on transportation over the Alster basin, a small district in the region of Osterbeck canal forming an exception; and the present tendency is not to encourage an increase of manufacturing business in this part of the suburbs, in order to preserve the beauty and attractiveness for residential purposes. There is a very extensive traffic of passenger steamers, and in summer the basin swarms with pleasure boats both for rowing and sailing. In winter, when the basin freezes up, the steamers keep certain channels open for a limited service, but as a rule have to stop running for a time, sometimes nearly two months, during which the traffic is diverted to the street cars. In such times there is a great deal of skating carried on, though the ice is somewhat impaired by the action of the steamers.

Altogether, the Alster basin, with its picturesque surroundings and the beautiful walk along its shores, forms one of the chief attractions that give Hamburg the name of a beautiful city, and is the pride of its inhabitants and the admiration of visitors.

RICHMOND LOCK AND WEIR.

THAMES CONSERVANCY, VICTORIA EMBANKMENT, E. C., Jan. 27, 1902.

DEAR SIR: — Replying to your letters of the 17th and 21st ult., I have to inform you that the only printed description of the tidal weir at Richmond appeared in "Engineering" of January, 1896, a copy of which I send you.

The weir, which is under the control of the Conservancy Board, is a half tidal one, and keeps up a head of about 5 feet 6 inches at low water. At one side is a lock and at the other side is a boat slip for the passage of rowing boats, and over the weir is a double foot-bridge.

The effect of this weir is to cause a certain amount of accumulation of mud below it, and it has also lowered the level of low water for a great distance down the river; but its effect on the régime of the river as a whole cannot be said to be injurious.

There are also three sluices, each 66 feet long by 12 feet deep, working on friction rollers, and so accurately counterbalanced that each sluice can be easily raised or lowered by two men working at the winches which control them. They are Stoney's patent, and were constructed by the firm of Ransome & Rapier of Ipswich, who have constructed a large number of sluices on this principle, and are now supplying the sluices for the irrigation works on the Nile.

If you desire to have a tracing, showing plan and elevation of the weir, with a copy of the tidal diagram taken below the weir, I could arrange for this to be furnished to you. The expense would not exceed £15.

I regret I am unable to reply categorically to the various questions your letter contained.

I am, dear sir, yours faithfully,

R. PHILIPSON,
Secretary.

HENRY S. PRITCHETT, Esq., *Chairman,*
Committee on Charles River Dam,
Room 203, 14 Beacon Street, Boston, Massachusetts.

THAMES CONSERVANCY, VICTORIA EMBANKMENT, E. C., May 10, 1902.

DEAR SIR: — Referring to your letter of the 18th of February last, I have now obtained the following information, which I think is what you require.

The effect of Richmond weir has been to lower the level of extreme low water below the weir from 5 to 6 inches. The lowering cannot be traced beyond a distance of about 3 miles from the weir.

I am sorry that, owing to the serious illness of our engineer, I have not been able to reply to you before.

I am, dear sir, yours faithfully,

R. PHILIPSON,
Secretary,
per F. A.

J. W. LUND, Esq., *Secretary*,
Committee on Charles River Dam,
Room 203, 14 Beacon Street, Boston, U. S. A.

COUSENS WHARF.

APRIL 10, 1902.

To HON. HENRY S. PRITCHETT, COL. SAMUEL M. MANSFIELD and HON. RICHARD H. DANA, *Committee on Charles River Dam, 14 Beacon Street, Boston, Mass.*

GENTLEMEN: — On behalf of my client, Harriet S. Cousens, executrix of the will of Horace Cousens, I submit for your consideration the following statement of the manner in and the extent to which it is believed the property known as the "Cousens coal wharf" would be injured by the erection of a dam in the Charles River basin.

The property known as the "Cousens coal wharf" is located at 781 Commonwealth Avenue, near the Cottage Farm station of the Boston & Albany Railroad. It contains a little less than 60,000 square feet, has a frontage of 200 feet on Commonwealth Avenue, and runs back some 300 feet to the Charles River, on which it has a frontage of over 200 feet. A large coal pocket and numerous coal sheds with engines and the apparatus necessary for unloading the barges are on the premises, and, with the dock, represent an investment of not far from $30,000 over and above the value of the land.

The larger portion of this property was bought in 1869 by Horace Cousens, and has ever since been used and occupied as a coal yard and wharf. The peculiar situation of this land, located as it is on deep water, and yet within easy teaming distance of the Back Bay, Brookline, Brighton, Cambridge and parts of Newton, and near many large manufacturing plants, renders it especially adapted to the purpose for which it is used.

The volume of the business, as shown by the increased tonnage, is constantly growing, and within the past four years it has increased from about 20,000 to almost 32,000 tons, due in part, probably, to the increase in the population of the Back Bay and the Longwood districts. There is every reason to suppose that, unless interfered with by some untoward incident, such as it is feared the proposed dam would be, the business will continue to gain in the same ratio in the years to come; and it is estimated that by the end of the year 1905 the net tonnage coming to this wharf will be at least 40,000. The Cousens

Coal Company, on account of this rapid increase in the past and expected increase in the future, has put in at great expense new and improved machinery and apparatus for the more rapid and economical handling of the coal. If the means of transportation by water were taken away, these improvements would be almost a total loss, as they could not be adapted to a business where coal was delivered by rail, and as the expense of removing such large and heavy apparatus and buildings to another location on tide water would be so great as to be prohibitive.

A few hundred feet up stream from Harvard bridge there is a bar over which at mean high water the depth is about 16 feet; and, as the depth of water in the Cousens dock and in the channel of the river directly in front of it at mean high water is 18 feet, any vessel which can come up over the Harvard bridge bar can come into the Cousens dock.

The property belongs to the estate of Horace Cousens, and is subject to a lease to John E. Cousens for eleven and one-half years from Dec. 1, 1898. The lessee, John E. Cousens, was a partner in the old firm of Cousens Brothers, coal dealers, and is its successor in that business.

During the past year, from Feb. 1, 1901, to Feb. 1, 1902, 31,803 gross tons of coal were delivered at the dock. This coal came directly by water from Pennsylvania, New York and Maryland, in the barges of the Philadelphia and Reading, Lehigh and Wilkesbarre, Delaware and Hudson, and the Susquehanna and Western coal companies. To transport this amount, 30 barges were required, varying in length from 175 to 210 feet, in beam from 30 to 35 feet, and in draft from 14 to 15½ feet. On an average, one barge is delivered and discharged in the course of every ten working days. The ice occasions but little trouble, and during the past winter two barges were delivered in December, two in January and one in February; and it is very rare that the ice delays a barge long enough to cause inconvenience.

Should a dam be built to retain a basin of fresh water, it is to be feared that ice would form soon after Thanksgiving and remain until the latter part of February, — say for two months and a half. During this time it would be impossible, unless a channel was kept open by artificial means, to use the river for purposes of transportation; and the Cousens Coal Company would be forced at considerable expense to enlarge its storage capacity, that it might have all its coal on hand before the ice formed, or to abandon its present policy, and contract for coal to be delivered by rail during the winter months. While the tracks of the Boston & Albany Railroad run within a short distance of this property, no coal is taken on in this way. It has always been considered impracticable to run a spur track into the yard, because one or more streets would have to be crossed, and considerable private property intervenes, over which rights of way would have to be acquired. The cost of transshipping by teams from the cars to the yard, while the haul is short, would be so great as to be almost prohibitive. If the other method, enlarging the storage capacity, be adopted, it would entail a large expenditure, as the storage capacity would have to be doubled and the insurance largely increased. Moreover, a large amount of capital would be tied up, as the coal, which has to be paid for within thirty days, or say by the middle of December, might not be delivered to customers or consumers before the middle of February.

It is a well-known fact that the cost of carriage by water is much less than by any other known form of transportation, and it is an almost equally well-known fact that the cost of carriage and storage are two

of the principal items to be considered in fixing the price of coal. Situated as the Cousens coal wharf is, on what is practically deep water in the midst of coal-consuming communities, it is enabled, under present conditions, to bring coal direct from Pennsylvania and other coal-producing centres to its wharf without once breaking bulk. It is enabled, always eleven and frequently twelve months in the year, to bring to its dock barges having a capacity of at least 1,200 tons, which is about the average size of the barges used in the coal trade. The cost of carriage, insurance, etc., is proportionately much less in barges of this size than in those of a capacity of from 200 to 800 or 900 tons. To a proper and profitable conduct of the business, it is desirable and necessary to secure the largest class of vessels. The length of time consumed in coming up to the Cousens wharf from the upper harbor depends so largely on the good or ill fortune which may befall the barge in the matter of securing quick openings of the different draws, that there is considerable variation in the time and consequently in the expense; usually the whole of a flood tide is allowed; if smaller barges are used, more frequent openings will have to be made of the various draws, delaying both the barges and the passengers who cross the different bridges. That smaller barges will have to be employed above the dam, if it is built, is almost certain. The barges which now come up to the Cousens wharf draw on an average a little over 15 feet, and the extreme draft which can be had is, by reason of the bar above the Harvard bridge, 16 feet. If the dam is built, and the water maintained at grade 8, and if it is assumed that no sewage or other matter will come into the basin to fill it up, but that the bottom of the basin will remain in its present condition, then the extreme depth of the channel will be reduced to 13½ feet, necessitating the use of barges having a draft of at least two feet less than those now in use. This means the use above the dam of barges having between one-half and two-thirds the carrying capacity of those now employed. Moreover, if the water is to be fresh instead of salt, as at present, the possible draft will be further reduced, by reason of the lesser buoyancy of the fresh water.

Should the coal be brought in the large barges as far as the upper harbor, and there transshipped to smaller barges or lighters which could go through the lock in the proposed dam and come up through the shallower channel, the increased cost, as estimated by the Boston Tow Boat Company, would amount to 60 cents per ton. One other course still remains, viz., bringing the coal all the way from Pennsylvania in barges having a draft suited to grade 8. A conservative estimate would seem to show that the largest barges which could come up to the dock with this depth of water would have a draft of not over 13 feet, and this would mean that their carrying capacity would be at least one-third less than that of the barges which can and now do come up to the Cousens dock. Various estimates as to the cost of transporting coal in barges having a carrying capacity of between 700 and 900 tons have been obtained, and, while the difference between rates of freight for small vessels and barges is a very uncertain and variable quantity, it has been found that the average cost of carriage alone, exclusive of increase drawbridge tolls, in such barges will exceed the average cost of transportation by barges such as are now being used by at least 10 cents per ton. This would mean that the cost of transportation alone would be increased by the sum of $3,180.30, reckoning on the basis of the 31,803 tons delivered the past year, or, on the estimated tonnage in 1905, $4,000. If the coal is brought in large barges, the cargo broken in the upper harbor and brought up on lighters, the increased cost of transportation would be 60 cents per ton, and for the past year would

have amounted to $19,081.80, or, as estimated for 1905, $24,000. The increased cost of transportation by rail would probably exceed even this latter figure, even if an arrangement could be effected for bringing a spur track directly into the coal yard. No accurate estimate has been or can be made of the increased expense which would have to be incurred if it became necessary, by reason of the ice, to lay in all the winter's stock of coal in November; but the following may show in a rough way what is anticipated.

If the dam is built, it is almost certain that ice would obstruct and prevent navigation soon after Thanksgiving. If business increases, as there is every reason to expect that it will, this means that when the dam is completed the whole mid-winter stock of coal, or from 12,000 to 15,000 tons, will have to be in storage by December 1. The present nominal storage capacity of the dock is 12,000 tons, but the actual storage capacity, owing to the number of different kinds and sizes of coal which it is necessary to carry, is below 10,000 tons. To accommodate this extra amount of coal it would therefore be necessary to enlarge the present storage capacity by at least one-half. The present shed cannot be added to in height, as the foundation is built on piles, the number of which was based on a maximum load of about 10,000 tons. It cannot be increased laterally, as the space now used for a driveway is no larger than is required to operate the 25 or 30 carts which are employed. The only remaining course is to fill in the dock, which, as has been said, enters the property at right angles to the channel of the river, and to build a new shed on the land thus created. A retaining wall at least 100 feet long would have to be constructed along the river front, the present dock filled in and piles driven. At least 200,000 cubic feet of filling, and possibly more, would be required for this. No estimate for this work has been obtained, but it is supposed that it would cost at least $15,000. The shed which would be built on this lot, the alterations to the machinery and hoisting appliances to adapt them to the new requirements, and the new machinery which would be necessary, would cost, it is estimated, $25,000. At average prices, 15,000 tons of coal would cost about $63,000, which would have to be paid for within thirty days after delivery, or by the 1st of January. Selling it at retail, some of it would be paid for in thirty days and some in six months; it is perhaps fair to say that at least three months' interest on the whole amount would have to be paid before the coal could be turned. This, at 6 per cent., would amount to $945, and the interest on the new buildings, machinery and dock, at $40,000, would be $2,400 per year.

The new drawless bridge will undoubtedly cause inconvenience, but it is not anticipated that the bridge will necessitate, as will the dam, extensive and expensive alterations and additions to the plant itself. No definite plans have been made as to the course to be pursued when the bridge is completed. The trouble, if any, will come with the masts which are now required by the insurance companies. The masts on the barges as now used, it should be understood, are single sticks, with no topmasts. It has been suggested that an arrangement is practicable whereby two short masts can be rigged, the upper, or topmast, sliding down into the lower, or mainmast, which is to be hollow; or the topmast might be housed, after the manner of an ordinary topmast on a schooner or other vessel. Another suggestion is to have the lower portion of the mast comparatively short, and to attach the upper part of the mast to the lower by a hinge or joint, as is done in Holland and in parts of Germany. It is said that both of these suggestions are practicable, and have been in use elsewhere with success.

Still another suggestion is to run mastless barges direct from New York by way of the Sound, thus incurring as few risks as possible, as no insurance could be obtained on a wholly mastless barge. It is understood that certain firms pursue this method now during the summer months.

The dam, it is feared, may complicate navigation with empty barges under the bridge; and both together, even if the channel should be dredged, may force the use of smaller barges than would be necessary if the bridge or the dam alone were constructed. The bridge is to have 26 feet clear headway above mean high water, or 28 feet above grade 8. A barge has from 2 to 5 feet free board when loaded; it also has a cabin, the floor of which is flush with the deck and the roof of which is at least 7 feet above the deck. On top of this cabin is usually placed the wheel house, which adds 7 feet more, bringing, with a free board of 4 feet, the top of the wheel house about 18 feet above the water line. (As a matter of fact, the top of the wheel house is usually much nearer 20 than it is 18 feet above the water line, but a height of 18 feet serves to illustrate the trouble which is anticipated.) With hinged masts, the loaded barges can easily pass under the bridge at mean high water if there is no dam. If the channel is dredged, they could pass underneath even if a dam is constructed. A barge drawing 15 or more feet loaded will after discharging cargo set about 10 feet higher than before; the top of the wheel house will then be at the very least 28 feet above the water line. This unloaded barge, if there is no dam, can pass underneath the bridge by waiting for half tide, when there will be 31 feet clear headway and over 6 feet of water under the bridge. If a dam is built, the clear headway will remain constant at 28 feet, and the empty barge will have great difficulty in passing out.

It would therefore seem that, if a dam is built and the water maintained at grade 8, the Cousens property, on an expected business of 40,000 tons, would at the very lowest estimate be put to the additional expense yearly of at least $7,495, which, at 6 per cent., represents an investment of $124,916.67. These figures are arrived at as follows:—

		Annual Interest Charge.
Cost of additional buildings and machinery for winter supply, ...	$25,000 00	$1,500 00
Cost of filling dock and piling, ...	15,000 00	900 00
Amount of extra capital represented by increased insurance on coal, ...	2,500 00	150 00
Amount of capital represented by increased interest account on winter coal, ...	15,750 00	945 00
Amount of capital represented by increased cost of transportation in barges drawing about 18 feet, on estimated yearly tonnage of 40,000, at ten cents per ton, . . .	66,666 67	4,000 00
	$124,916 67	$7,495 00

For the reasons above stated, it is feared by my client that the construction of the proposed dam will seriously and materially interfere with the business which has been carried on on her property for over forty years, and cause great damage to the interests of the estate of which she has charge.

Should the committee desire further information in regard to the business or its management, I shall be glad to supply it.

Very respectfully yours,

E. B. BISHOP,

Attorney.

STATEMENT OF THE BUTCHERS SLAUGHTERING AND MELTING ASSOCIATION.

Committee on Charles River Dam.

GENTLEMEN: — The Butchers Slaughtering and Melting Association, popularly known as the Brighton Abattoir, is, as its name indicates, a butchering and rendering corporation. It is located in that part of Boston formerly the town of Brighton, on the banks of the Charles River, about 4¾ miles from its mouth.

This corporation commenced business in 1873, with an investment of half a million dollars, and the property has been improved and increased from time to time until at the present it represents an investment of between $800,000 and $900,000. There is a frontage upon the river of 3,446 feet; of this, 565 feet is improved wharf. There are also 204 feet of stone frontage to the harbor line and 612 feet of sea wall, with the right to extend 20 feet to the harbor line, as laid down by the United States government. Of the improved wharf the corporation occupies 265 feet for its own purposes, and 300 feet are occupied under a long lease by Brackett & Son, coal merchants. The sea wall was constructed only a few years ago, at an expense of about $50,000, and the wharf occupied by Brackett & Son is also of recent construction. The physical condition of the land at this point makes our river frontage a particular necessity to us, in that back from the river there is a steep gravel bank, which allows access to our premises only at either end along the river bank, to Western Avenue in one direction and North Beacon Street in the other, each highway being about a quarter of a mile distant from our plant.

The circumstances connected with the organization of this company are peculiar, and should, we believe, be considered by your committee in connection with its rights.

Prior to the year 1870 the numerous slaughter houses of Brighton were scattered over a large portion of the town, and were in many instances in close proximity to its business and residential portions. The disadvantages of this do not need to be pointed out. At the same time, however, the industry was of great importance to the community.

One of the first acts of the State Board of Health, organized in the year 1869, by chapter 420 of the Acts of that year, was to insist upon the regulation of the butchering establishments of Brighton, and as a result of its efforts a statute was passed, chapter 365 of the Acts of the year 1870, creating this corporation. The selectmen of the town were named as the incorporators, and the corporation when formed was compelled to locate in such place as should be designated by the Board of Health. Provision was made for the taking of land and for the awarding of damages, and the business of the corporation was placed under the control of said Board.

For many reasons the butchers opposed this move, and it was only after a stubborn fight that the Board of Health succeeded in compelling the different individuals who were carrying on the butchering business to comply with the provisions of this statute. The corporation was, however, at length formed, the stock being subscribed for by the butchers themselves. The corporation is not, therefore, the result of private or individual enterprise, which sought to profit by the advantage which the location upon the river afforded, and which it might be said in locating upon the river took the chance and accepted the possibility

of having the advantages of that river curtailed by such use as the State might see fit to make of other parts of it. It is a corporation, the organization of which was forced by the State, the location was chosen by the State, and the butchers of Brighton were compelled either to see that the stock was subscribed for or else give up business in that locality. Our rights may be no greater because of these facts; but we submit to you, gentlemen, that we are entitled to special consideration from the State, because of the nature of their inception. It is hardly fair that the State should compel a company to locate at a certain point, and then proceed to take away from it the advantages which the location affords.

The original act of incorporation of the company was amended by chapter 144 of the Acts of the year 1876, which further limited the privilege of butchering within the city of Boston to the premises of this one establishment, and placed the business there conducted under the Boston Board of Health.

Until the creation of the Metropolitan Park Commission in 1893 the policy of the State and of the United States was to improve the facilities for navigation upon the Charles River. Encouraged by this policy, and by the advantages which the corporation found its location afforded, it has, as previously indicated, pursued the policy of increasing the investment in its plant, and has each year carted a large amount of gravel from its gravel pit into a low, swampy portion of its property, thereby increasing the available water frontage. Figures showing the amount of tonnage passing the proposed location of the dam and the depth of water have been presented to you by others, and we shall refer but briefly to such figures as apply only to our wharf.

The water frontage is used, as we have stated, not only by us, but by a tenant under a long lease, who sells his coal in Newton. Before being located as at present the sheds of this tenant were in Newton, and they came to the Charles River because they found that they could bring their coal up the river and then cart it two miles to Newton more cheaply than they could take it from Boston to Newton upon the railroad. At high tide there is a depth of 12 feet of water at my client's wharf, and in the last few years an average of 20,000 tons of coal per annum have been delivered there, — about 3,000 tons for the corporation and 17,000 tons for Brackett & Son. But these figures do not adequately represent the value of the water frontage. A large portion of the coal which is used on our premises at present is not brought to our wharf by boat, but is transported by rail. The Bowker Fertilizer Company, the Boston Fresh Tripe Company, John Joyce, coal merchant, and Donahue, granite cutter, are all tenants upon the premises of the corporation. The first two companies use a large amount of coal in the carrying on of their business, in addition to the amount Joyce brings there for sale; and in addition to the coal there is from each of the three, excluding Joyce, a large amount of heavy shipping. In some ways it is more convenient to utilize the railroad, and it is possible to make advantageous rates with the railroad because of the presence of the river, — an advantage which would, of course, be immediately lost if access to the river were cut off, leaving us and our tenants dependent solely on the railroad, as is the town of Newton.

Any figures will, we believe, show that the amount of commerce upon the river has decreased within the last few years; but we wish to call to the attention of you gentlemen the fact that the policy of the Metropolitan Park Commission in taking property along the river is responsible for this decrease. By making this statement we do not, of

course, mean to suggest a criticism of the policy of taking the land along the river for park purposes, for, whatever one's opinion on that subject may be, the takings are an accomplished fact, and must be accepted as such. It must, however, be borne in mind that the decrease in business which has occurred is brought about by an enforced condition, and not because the Charles River is ceasing to be a place where commerce can be carried on advantageously. In fact, during the last few years we have had several different concerns consider the advisability of locating their plants upon, or else taking leases of portions of, our premises, because of the business advantages afforded; but in every such instance the feeling of uncertainty as to what policy the State might adopt towards the river has dissuaded such persons from locating upon the Charles.

As you gentlemen are aware, some of the advantage of our location has already been taken from us, or is shortly to be taken from us, by the construction of the new West Boston bridge without a draw, for when that bridge is constructed there will only be headroom of 26 feet at mean high water. Much has been said upon this subject, to the effect that our rights are not materially affected by such a bridge, in that it will still be possible to pass under the bridge with mastless barges or barges with hinged masts; but at the present time — and we state this upon the authority of several gentlemen with whom we have talked — the hinged mast is only used on small pleasure craft, and the mastless barge as a carrier of ocean freight is not an accomplished fact to any extent whatever. There are a few, we believe, in use upon Long Island Sound; but the marine insurance companies tell me that they will not insure a mastless barge; and in the severe storm in the winter of '98 — the storm in which the "Portland" was lost — practically all of the mastless barges, we have been informed, that were out were lost. The ordinary barge has, for use in case of necessity, an equipment of sails, which makes it manageable and able to protect itself in case the tow is broken, although it does not use these sails except in emergencies or as a mere auxiliary; but this discussion is hardly relevant in the present consideration. The fact is, that when the proposed bridge is constructed a large portion of the freight carried upon the Charles River will be subjected to the expense of transshipment, or else barges will have to be equipped with some form of hinged mast, — a proposition the utility of which has not yet been proven.

The bridge has been authorized, although an authorization of its construction without a draw was first refused by the War Department, which had jurisdiction in the premises, and was only finally authorized by an act of Congress, which was not passed until a proviso was added requiring the Commonwealth of Massachusetts to pay wharf owners damages for all injury that might be done to their property through interference with access by water to their property.

The proposed dam, if it is authorized, even with the most commodious locks, will further curtail our access by water, in that it will lessen the depth of the water from mean high water 2 feet, will fill the basin with a less buoyant water, and will render it almost impossible to keep the basin free from ice for a few months of each year. This matter of freezing will not be a very serious hindrance to us at the present time, but it will, of course, curtail our possible future use of the river. To Brackett & Son, however, the freezing of the river will be a very serious matter, for, although at the present time they have to be prepared to carry a very considerable amount of coal through the winter, they would, to protect themselves in the event of the construction of

the dam, have to expend $3,000 or $4,000 in increasing their storage capacity, and would have to lay in an extra supply of coal, which would amount to the tying up of $16,000 or $17,000 of extra capital, besides extra insurance thereon. The dam will also, taken in connection with the drawless bridge, prove a serious hindrance; for, although without the dam it may be possible, if some form of hinged mast is devised, to go under the bridge at high water with loaded vessels as large or almost as large as those in use at the present time, and to return at low water with such vessels empty standing high out of the water, yet when the dam is built it will not only not be possible to use vessels with quite as deep a draught, but the impossibility of vessels returning unloaded to pass under the bridge will make it necessary either to change completely the construction of the hulls of the present vessels, or else to tranship all the coal and take it up the river in barges, which will, of course, entail an increased expense. But we shall not go into a discussion of this part of the question, as Mr. Cousens has, we believe, dealt with it fully in the statement which he has submitted to you.

For business reasons, then, for the protection of our property and of the capital which we have invested in it, and for the sake of extending by rental and otherwise the natural earning capacity which our property has, we are opposed to the construction of this dam. We realize, however, that there are comparatively few persons left who are interested in the proposition from a business stand-point, as we are, and we do not wish to oppose too strenuously a plan which may be considered advantageous by the municipalities and by the greater number of citizens along the banks of the river; but our rights, although comparatively small and possessed only by a few, are as sacred as the personal rights of any other persons, and entitled to as much consideration; and we contend that your committee should in all fairness, if it deems it best to report in favor of a dam, make such provision as it can to provide for our needs, by the construction of commodious locks, dredging the channel and keeping it open in winter, and should, we contend, provide for the payment to us of damages for the injury which we must suffer. As a matter of law, no damages would, probably accrue to us, as the injuries to be suffered by us would be consequential. In many instances Legislatures have not considered the proposition of granting damages in such cases advisable; but there are two particular reasons, outside of the general consideration of fairness, why damages should be given in this case.

In the first place, a precedent has been established, and upon this very river, by the act of Congress passed March 29, 1900, authorizing the West Boston bridge without a draw; and, in the second place, the particular facts of this case are peculiar. We have already pointed out the circumstances of our organization. In addition, the Metropolitan Park Commission has taken all the land along the river that it can afford to take, and would have taken our property and the property of the few others who are left, had it not been that because of the advantages we possess it is too valuable for them to take. At some future time they may take it, and, in fact, they cannot complete the park system as now planned without doing so. I can frankly tell you that we hope that the Metropolitan Park Commission will not take our land, for what we desire most is the privilege of being left alone, and being allowed to conduct our business in the locality we have found advantageous for it, and to utilize our capital for the purposes for which we have invested it; but if that is not possible, and if we are some day to have our land taken from us by the State, we submit to you, gentlemen,

that it is not fair for the Commonwealth of Massachusetts to adopt a policy which will so lessen the value of our property that the Commonwealth may purchase it at a later time at a very reduced figure, and yet not pay us for any damages we have suffered.

BUTCHERS SLAUGHTERING AND MELTING ASSOCIATION,

By WARREN & GARFIELD,
Attorneys.

REVERE STREET WHARF.

ROOM 505, TREMONT BUILDING, BOSTON, March 7, 1902.

To the Committee on Charles River Dam, Boston, Mass.

GENTLEMEN: — I am the owner of about 25,000 square feet of land fronting on Charles River, foot of Revere Street (city proper), and said property is now and has been for a long time used as a wharf. Number of vessels landing at my wharf is about 60 per year; draft, about 12 feet; tonnage, 1,200 to 1,500. I shall expect to be fully compensated for any and all loss or damage sustained by the building of one or more dams in Charles River, and trust that, if your committee should decide to recommend the construction of a dam, and the same be constructed, my interests, as well as the interests of others similarly situated, will be protected by law, so as to fully compensate me and them for any and all loss or damage done to our property by the building of said dam.

Otherwise, I should want to go on record as a remonstrant.

Very truly yours,
J. J. COSTELLO.

FENWAY. — STATEMENT BY MOORFIELD STOREY, ESQ.

735 EXCHANGE BUILDING, BOSTON, Feb. 3, 1902.

President HENRY S. PRITCHETT, *Massachusetts Institute of Technology, Boston.*

DEAR MR. PRITCHETT: — As you are the chairman of the committee which is considering the plan for improving Charles River basin, I write in behalf of myself and my neighbors on the Fenway to express our hope that if any plan is adopted provision will be made for the sewage which now passes into the Charles River from the Fenways. When there is a heavy rain, and under certain conditions which occasionally occur, a great deal of sewage finds its way into the water which passes out through the Charlesgate, and I think there is always more or less, though on that point I am not clear. If the flow of the stream is slackened there is of course some danger that this sewage

PART OF THE

COMMERCIAL DISTRICT

OF

CAMBRIDGE

1902

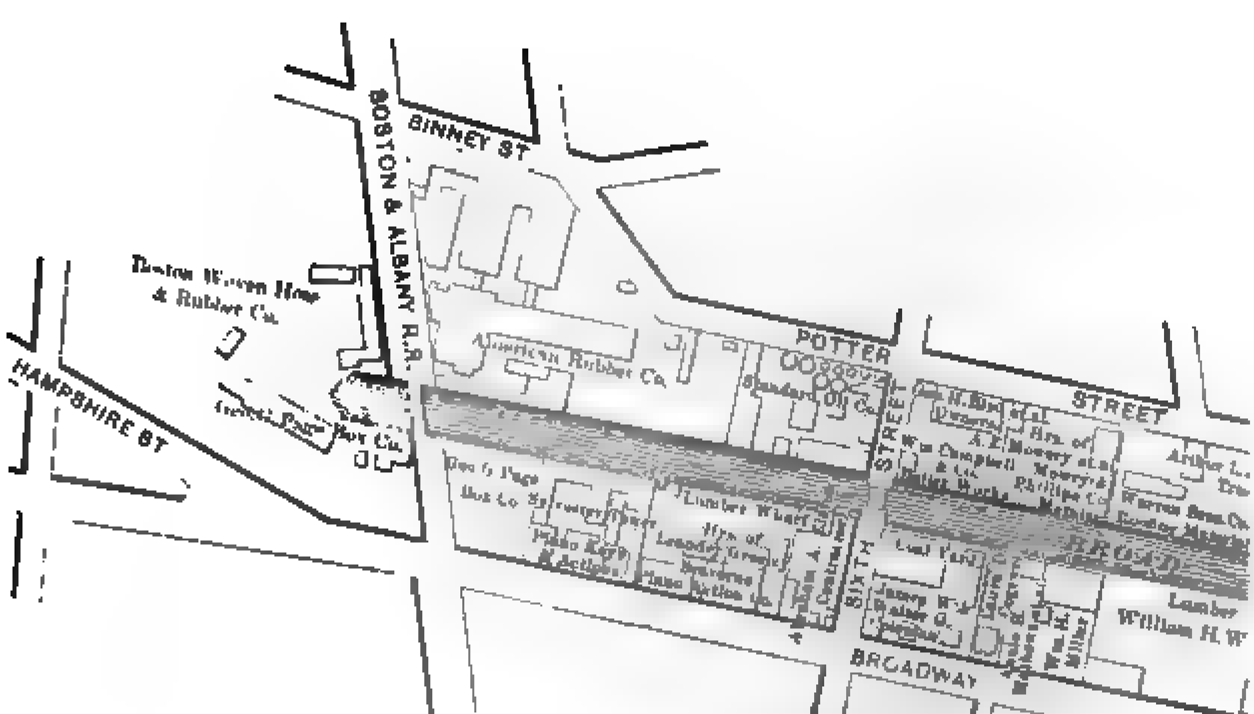
0 100 200 300 400 800

Scale of Feet

CHARLES D. ELLIOT,
Engineer.

This Plan Shows the Water Front Properties of Cambridgeport and East Camb

The Adjacent Manufacturing District About [illegible] Acres is not Shown Hereon



will settle and in time become a nuisance. As it is, the depth of the water is materially reduced, as I understand it, by the settlement which has already occurred. I have no doubt that you have had your attention called to this matter, but by way of precaution I venture to renew the suggestion, being glad that the matter is in such good hands.

Yours sincerely,
M. STOREY.

THE PROPOSED CHARLES RIVER DAM AND THE COMMERCE AND INDUSTRIES OF CAMBRIDGE.

BY CHARLES D. ELLIOT.

I.

In considering the desirability of the proposed dam across Charles River, the question of the preservation and future growth of the commercial and manufacturing interests of Cambridge enters, as one of the most important factors.

The eastern section of Cambridge bordering on the river from Craigie bridge to West Boston bridge, and upon the Broad and Lechmere canals, and extending westwardly to and beyond the Boston & Albany Railroad, is almost entirely a manufacturing and industrial district; it comprises nearly 200 acres of territory, and has a water frontage on river and canals of about 2¼ miles, nearly 2 miles of which are at present commercially occupied. Its direct connection with railroad systems east and west, together with its large and deep water basin and deep channels through the bridges, give it excellent freight facilities, and ensure its future as an important receiving and distributing centre.

The business establishments of this section were assessed in 1901 for nearly $5,100,000, and their annual trade, estimated upon the best information obtainable from proprietors and other sources, is probably over $5,000,000, — which estimate I think is conservative.

The river basin between West Boston and Craigie bridges has an area of 3,574,000 square feet, or about 82 acres. Of this, 1,700,000 square feet has a depth of 12 feet or more, and nearly 800,000 square feet of 18 feet or more, at mean low tide. The entrance to this basin through Craigie bridge draw has a depth of 24 feet at mean low tide. Forty vessels with drafts of 18 to 22 feet and 50 more drawing from 12 to 18 feet, could lie in this basin at low water. The saving by water over railroad transportation is from 35 to 50 cents per ton for coal, $2 to $2.50 per thousand feet for lumber, $1 to $2 per ton for granite, and for other materials in about the same ratio. The anticipated shipping business of this basin and water front for this year, based on statements made by the various proprietors, is substantially as follows, viz.: —

Coal (tons),	264,000
Lumber (feet),	38,000,000
Oil (barrels),	200,000
Granite and marble (tons),	78,000
Piles,	50,000

and other materials, such as brick, lime, castings, iron pipe, sand, gravel, cord wood, tar, etc., — in all, a shipping trade estimated at $2,460,000.

A plan submitted in connection herewith shows this river basin between Craigie and West Boston bridges, the canals, and the water front properties and plants, which constitute the commercial portion of the district, which water front properties had an assessed value in 1901 of about $2,900,000. The numerous manufacturing establishments contiguous to this commercial frontage, and largely dependent upon it for coal and other materials, are not shown on this plan; they had an assessed value in 1901 of about $2,200,000.

The following is a list of the principal business concerns in this section of the city, viz.: —

J. W. & W. G. Coleman, coal.
Barber Asphalt Paving Company.
Damon Safe and Iron Works Company.
A. & J. B. Ford, granite.
Cambridge Gas Light Company.
Seavey Manufacturing Company, stamped ware.
Smith-Warren Company, sheet metal.
Wm. Campbell & Co., boiler works.
Standard Oil Company.
American Rubber Company.
Boston Woven Hose and Rubber Company.
Geo. G. Page Box Company.
Sylvester Tower, piano actions.
Heirs of L. Greely, lumber and carpentry.
Seaverns Piano Action Company.
A. A. Elston, contractor.
Wm. H. Wood & Co., lumber.
Bay State Fuel Company, coal.
Cambridge Electric Light Company, coal.
Walter W. Field, machinery.
Howard Coon, contractor.
John J. Horgan, marble.
Rawson & Morrison Manufacturing Company, boilers, etc.
Proctor Bros., hay and grain.
E. Ricker & Son, granite.
Wellington-Wild Coal Company.
Charles Linehan, contractor.
John S. Clary, lumber.
S. & R. J. Lombard, granite.
D. Proudfoot, coal.
Enos D. Sawyer & Co., lumber.
Parker & Page, lumber.
John Harrington, granite.
Chas. E. Hall Bro. & Co., marble, etc.
John T. Scully, piles.
Barbour, Stockwell Company, railway supplies.
Charles River Iron Works.
Roberts Iron Works Company.
Athenæum Press, E. Ginn & Co.
Henry Thayer & Co., manufacturing chemists.
Alden Speare's Sons Company, mill supplies.
Boston Bridge Works.
Mason & Hamlin Company, organs.
American Linseed Company.
American Net and Twine Company.
Geo. F. Blake Manufacturing Company, pumping machinery.
Irving & Casson, wood mantels.
Curtis Davis Company, soap manufactory.
Chelmsford Foundry Company.
John C. Dow & Co., soap.
Connecticut Steam Stone Company.
Dennis, Thompson Pierce Company, coal.
Goepper Bros. Company, steam barrel manufactory.
Viscol Company.
J. H. Roberts & Co., machinery.
F. L. Goldsmith, hardwood lumber.
Independent Ice Company.
Sawyer Belting Company.
Otis Wood Works.
Keeler & Co., furniture manufactory.
A. B. & E. L. Shaw Company, furniture manufactory.
Seelye Manufacturing Company, shoe machinery.
Sweat & Gould, granite works.
A. H. Davenport, furniture manufactory.
J. H. Keenan Company, sawmill.
Builders Iron and Steel Company.
Independent Bundle Wood Company.
Ames & McGinty, roofing.
Warren Bros. Company, copper roofing materials.
Broadway Iron Foundry Company.
Hugh Stewart & Co., carriage manufactory.

Mr. Emery, chairman of the Harbor Commissioners, in speaking of this part of Cambridge, says: "Many of these manufacturing plants were located in this locality after a thorough examination and exhaustive study." This, to my personal knowledge, was the case with two of the largest of these establishments. One proprietor says that, after examining the suburbs of East Boston, Chelsea, Everett, Charlestown, Somerville and Cambridge, the result was the choice of the present location in Cambridge; and also says: "We have never regretted our choice of location, and believe that the steady and large growth of business has been in no small degree due to the advantages of our situation."

The commercial and manufacturing establishments of this district give employment to thousands of skilled workmen and artisans; these and their families form a large part of the great communities of lower

Cambridgeport and of East Cambridge, upon whom local tradesmen and storekeepers are largely dependent, as are the real estate interests of those two sections, consisting mainly of tenement property. Any interference with the commercial industries of this district, either immediate or prospective, would therefore affect not only invested interests, but an extensive community as well.

Thirty or more years ago, over one-third of this territory of 200 acres was river flats and much of the remainder was unfilled marsh land. It has since been reclaimed and extensively built upon. Captain Smith, the drawtender at Craigie bridge, says that twenty-five or thirty years ago vessels larger than 200 tons seldom came through his bridge, but that the tonnage has constantly increased, until now vessels of 1,200 to 1,500 tons are common on the river.

The growth of trade in this basin is further emphasized by a comparison of the drawtender's returns for the years ending Jan. 31, 1894, and Jan. 31, 1902, showing the number of openings for vessels of all kinds that passed Craigie bridge, but did not pass West Boston bridge: —

	Draw Openings.
Year ending Jan. 31, 1902,	3,565
Year ending Jan. 31, 1894,	1,020
Increase in eight years,	2,545

II. Plans proposed by the Petitioners.

Three locations for the proposed dam have been suggested by the petitioners, viz., at Craigie bridge, at 650 feet above said bridge, and just below West Boston bridge. Two of these, the one at Craigie bridge and the one 650 feet west of it, apparently have their locks planned for the Cambridge side of the river, 115 feet from the harbor line, and are designed to have only 12 feet depth of water in the lock chamber at mean low tide (but 10 feet deep at low spring tides); so that all boats drawing over 10 or 11 feet must wait the rise of the tide before entering, barges drawing 15 or 16 feet being compelled to wait until about half tide, before being able to pass the lock. At Craigie bridge a lock 400 feet long, if on the Cambridge side, would mask the entrance to Lechmere canal. It would also require the draw in Craigie bridge to be located some 500 feet or more north-westerly of its present position, and to that extent out of line with the draws in the Boston & Maine Railroad freight and other bridges to the east; so that a barge with its tug emerging from the railroad freight bridge draw would have to turn abruptly to the right, and sail parallel to and between this bridge and the Craigie bridge for at least 500 feet, or to where the space between the bridges is not over 175 feet, and then turn again to the left, nearly at right angles, in order to pass through this proposed new draw. Some of these barges are 175, and some over 200 feet long, and have tow boats 70 to 80 feet long, and could not enter a draw so placed. As between 150 and 200 barges annually pass up, and, after discharging, repass through Craigie bridge, the result of placing the draw where proposed would prove prohibitive to a large part of the traffic of the basin, and would greatly annoy the remainder.

Ninety-eight per cent. of the domestic coal received at Boston comes by water, chiefly in barges, whose cargoes vary from 1,000 to 4,000 tons. Barges of 1,500 or 1,600 tons now go up Charles River into the basin and canals below West Boston bridge. Some of these barges are 203 feet long, 35 feet beam, and have a draught of 16 feet. The channels through the bridges below this basin with a small amount of dredging would allow the passage at low tide of barges with cargoes

of 2,000 tons or larger, and draughts of 20 or more feet. The openings of the new Charles River bridge are 50 feet in the clear; if this width of draw is adopted for the remaining bridges, which I understand are to be rebuilt before many years, these increased facilities, together with new devices for rapid unloading and economic handling of coal which are about to be introduced by proprietors along this river, will make the district bordering this basin one of the most important coal and commercial centres on the water front of Boston.

The largest vessels now plying the river will require a lock with a depth of at least 17 feet of water, and preferably 18 feet at mean low tide. The lock designed for the petitioners calls for only 12 feet of water on the sill at low tide, thereby reducing the present depth of entrance through the draw into the basin at low tide from 24 to 12 feet, and in effect creating a dam 6 feet high in front of the required 18 feet deep channel. I think the present location of the draw in Craigie bridge should be maintained, and the lock placed in line with it, in case the dam is built at said bridge; and that any lock built below the Broad canal to provide for the future should have 20 feet depth of water its entire length at mean low tide and clear width of chamber of at least 45 feet; and that channels wide enough for vessels to pass one another should be dredged from the lock to and through the canals, and be constantly maintained and kept open for shipping, of whatever character, summer and winter.

The effects of the proposed dam upon the navigable conditions of the river may be briefly suggested as follows, viz.: —

The tidal ebb and flow immediately below the dam would be reduced almost to stagnation, and that in the remainder of the river would be extremely sluggish, ultimately resulting in serious shoaling of the river below the dam.

Dredging will be required in the basin and canals to maintain channels of a needed depth of at least 18 feet at low water. Such dredging will render necessary the strengthening of sea walls, bulkheads and other structures.

It will require also the maintenance of channels through the fresh ice in the still-water basin, and through the salt ice which will probably accumulate outside the dam, especially during flood tide. When freshets and flood tides are coincident, the difficulty of maintaining open channels will be increased.

As salt ice forms at a much lower temperature than fresh, and is more fragile, it will be easier to maintain winter traffic in a salt-water than in a fresh-water basin.

If the basin is fresh water, and is frequently emptied and refilled in summer, as has been suggested will be necessary, long and serious interruptions to navigation are likely to occur, which will be almost entirely obviated if the basin is filled with salt water instead of fresh. If with salt water, it could be emptied and filled again to grade 8 in an average of eight hours, or within the ebb and flow of one tide; which, if done at night, would cause no serious interruption either to business or to pleasure on the river. To empty and refill the basin within one tide, and to promptly care for ice and freshets, tidal sluices would be required.

Salt water is less favorable to the growth of algæ than fresh, and is more conducive to a good sanitary condition of the river. The relative effects of fresh and salt water saturation upon the reclaimed lands adjacent to the river and canals, which are filled largely with ashes, is a question for consideration.

In case a dam is decided upon, wherever its location may be, its construction and that of the basin it impounds should be so planned and their permanent maintenance so provided for that the present shipping interests of Cambridge and their prospective and natural growth shall in no way be curtailed. Vessels drawing 20 feet or more of water can at present enter the basin at lowest tide; and, by dredging to a depth of 18 or 20 feet at low water to and along the river and canal frontage, ample facilities for the future increase of business will be provided.

Any scheme, therefore, for a dam at Craigie bridge, or 650 feet above it, which provides for a shallow, narrow or misplaced lock, and does not include tidal sluices, or fails to provide for the public maintenance of proper channels, especially in winter, or imposes lockage tolls, will deprive the shipping of Cambridge of the future possibilities which it now has, and will prove a permanent injury to the industries and growth of that city.

REPORT OF DWIGHT PORTER.

BOSTON, May 23, 1902.

Messrs. LEWIS S. DABNEY, CHARLES HEAD and HOWARD STOCKTON, *Committee.*

GENTLEMEN: — I beg to bring to your notice the following considerations bearing upon the proposition to construct a dam at Craigie bridge or thereabouts, and thereby to convert the lower Charles River into a fresh-water basin, to be maintained at a level some 8 feet above mean low water.*

1. The use of streams for carrying away domestic sewage and polluted surface water is as old and as legitimate, within bounds, as any other to which they are put. The lower Charles River has for an indefinite period served such a purpose, and, although it finally became overloaded with sewage, yet in the very undertakings entered into for its relief within the past twenty years its continued use as a convenient and economical adjunct of the great intercepting sewerage systems has been assumed and relied upon. I refer to the provision for discharge of dilute sewage during storms through relief outlets scattered along the water front, — a provision common with the larger cities throughout the civilized world. With its average ebb and flow of more than 300,000,000 cubic feet of sea water twice a day, the river is able to perform this duty successfully. But it has other offices to fulfil. I believe it to be a determining factor in establishing the level in the adjacent low land of the great sheet of ground water which is flowing slowly from the uplands towards tide water. By the intervals of low water between successive tides it permits of the easy removal, by gravity, of much of this ground water, and the draining of the soil to a depth of several feet below marsh level. The air from its surface is invigorating, and it provides salt-water bathing for many thousands of people. Vessels ascend the basin in every calendar month, and to the number of a thousand or more per year, while to Boston harbor the lower river lends aid in helping to maintain its channel by natural forces.

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* Strictly equivalent to grade 8.6 above Boston base.

In view of the importance of the sanitary and other interests concerned, it is certainly imperative, before trying an experiment costly in itself, and indirectly involving outlays to the cities of Boston and Cambridge to an extent which it is difficult to foresee, to obtain the strongest of proof that the resulting benefits will outweigh the injuries, and that they will be enough greater than those obtainable by simpler means to warrant the hazard and expense.

2. In discussing the possible methods of dealing with the Charles, reference is often made to the "water park" formed by the Alster basin at Hamburg, and to the recently constructed dam at Richmond, on the Thames, as precedents indicating what should be done here. The Fens basin, of about 30 acres, is to a certain extent a type of what is proposed in the Charles, and six years ago was referred to as a "water park" by the Boston Park Board in its annual report. No special recreative use has actually been made of this body of water, however, in the dozen years since it was formed. The conditions are manifestly different here from what they are at the foreign cities which have been named. Boston has at her doors an ocean park of unsurpassed attractiveness, while inland the country is dotted with natural lakes and ponds, both of which features are lacking in the cases of Hamburg and London. Hamburg is 60 miles from the sea, and London 40 miles. The Alster basin has been in existence for at least three hundred years, and all features of drainage have naturally become adapted to it; and even at the start it could have involved no change from salt to fresh water, such as is contemplated here. Furthermore, Hamburg is farther north than Boston by 800 miles, has a summer temperature 6 or 8 degrees cooler than that of Boston, and from its basin sewage of all kinds is said to be most rigidly excluded.

The Richmond dam on the Thames is 16 miles above London bridge and 25 miles above salt water. It would, perhaps, never have been constructed but for the fact that the removal of bridge piers and other obstructions at London resulted in a remarkable lowering of the low-water level at Richmond, the average rise and fall of tide there having been increased by two-thirds in less than twenty-five years, with the result of causing extensive exposures of mud flats, and vexatious interference with passenger steamer navigation.

3. It is suggested that more pleasing landscape effects are possible with a full basin than at present, because with it the sloping banks and shoals would always be covered, dikes would be unnecessary along the shores, and planting could be carried close to the water. So far as shoals proper are concerned, these have already been mainly removed by dredging. Over 3,000,000 cubic yards of material have been dredged from the river within the past eight years or thereabouts, and used as filling upon the adjacent shores, — for the Esplanade and the tract to the north of it, for the Speedway, the Cambridge Parkway, and for other purposes. This has been equivalent to an increase of water depth of about 2¼ feet over the whole proposed basin. A few acres of shoals, barely visible at mean low water, remain on the Boston side above Harvard bridge, and narrow strips, perhaps 25 or 50 feet wide, are here and there exposed for a short time at low water along the foot of the sea walls. On the Cambridge side of the basin the dredging mentioned above has substituted for the former shoals from 10 to 25 feet depth of water at mean low tide, and opposite the Speedway the dredging has been carried to 10 or 15 feet below mean low tide.

Of all the shore line from Craigie bridge to Watertown dam more than four-fifths has already been filled or diked high enough, or else is naturally sufficiently high, to guard against all but very rare tides;

and to dike the remainder in a manner similar to that employed at Captain's Island would cost perhaps $30,000.

The finished slopes now given to the shores at Captain's Island and along the Speedway appear to range in general from 1 vertical on 5 or 6 base to 1 on 12. With a fresh-water basin, turf could be extended toward the water farther than at present by a distance on the slopes corresponding to the vertical height between say grades 9 and 12, or from 15 to 35 feet. The roots of any plants or trees set as near the water as these figures assume would, however, be exposed to the salt or brackish water with which the basin must at times be supplied in the attempt to keep it wholesome, and the conditions of planting would be correspondingly restricted.

Inspection of the shore improvement effected along the course of the Speedway on the Boston side, and in the vicinity of Gerry's Landing on the Cambridge side (cuts A and B *), shows that an attractive appearance may be given the banks of the river, as it now is, without the building of masonry walls, which have sometimes been referred to as the only practicable method of treatment with a tidal basin.

4. With a dam, would the basin be extensively used for boating? The history of certain water ways controlled by the city of Boston discourages such an expectation. In 1895 the Boston Park Commissioners anticipated such employment of the Fens Basin, Muddy River and Jamaica Pond, and arranged for an elaborate equipment of the various waters with row boats, canoes, etc. A relay station was established at Brookline Avenue, so that there should be ready transfer, for those using the boats, from Muddy River to the Fens Basin, or the reverse. There has been practically no demand, however, for either boats or canoes on either of the last-named bodies of water. Two electric launches, even, were placed upon Jamaica Pond, but they have since been removed, from lack of patronage. The Cambridge Park Commissioners, prophesied in their report for 1897 (page 609 of annual reports to the city council), that the river would "within the next few years, be extensively used by electric launches for pleasure and for travel between Cambridge and Boston;" but so far as I have learned, no such use has developed. The only noteworthy employment of the lower Charles for boating is for shells, and those who row in these have little cause for complaint. Fifteen inches depth of water is considered sufficient in the rowing tanks at Harvard, and 2 feet in the river should be ample for rowing of all kinds. Existing maps do not give complete information as to the present water depths in the river, but from such knowledge as is available, I am satisfied that two feet depth of water can be found everywhere in the basin, and in the river itself as far up as the arsenal, except close to the shores, for at least 70 per cent. of the whole time during the year; and that throughout this stretch a sheet of water from 100 to 150 feet wide in the narrow part of the river, and 500 feet or more in width through the basin proper, with 2 feet depth of water, can be found for from 75 to 90 per cent. of the whole time.

So far as concerns rowing by children in ordinary boats, as on the Public Garden pond, that would be unlikely to become common, because of the danger associated in the mind with the greater depth of water, ranging from 20 to 30 feet over considerable portions of the basin; and still more because of the rough water, resulting from the wide exposure of surface, whenever there is more than a gentle breeze. From personal experience in boating on the river for a con-

* Cuts A and B not reproduced.

siderable number of years, I think this latter feature would be found with people of all ages one of the principal obstacles to the frequent use of the basin for rowing, and a much more serious one than the current of the present stream.

5. Would skating become popular upon the basin? This pastime is possible for a month or six weeks in the year, and increasing provision has been made for it from time to time by the Boston Park Commission. In the winter of 1900–1901 it was thus provided for in twelve different localities, well scattered about the city, at which there was a total approximate attendance of 480,000 persons.* But in the Fens basin skating is not permitted, because safe ice does not form; neither is there skating upon Muddy River; and even upon Leverett Pond it has been abandoned, because of the fatal accidents two or three winters ago, due to poor ice. The causes of poor ice in the Fens basin are thought to be the warmth of the water coming in from Stony Brook; the admission of salt water from the Charles to purify the basin; the current which is thus induced, and which wears away the under side of the ice; and the fluctuations of level, which, though not large, are sufficient to break the ice along the shores. All these influences should be expected to operate to a greater or less extent to prevent the formation of safe ice over much of the proposed basin, especially over the lower portion, which is adjacent to the densest population, and where the greatest patronage would naturally be anticipated. During the past winter it could be seen that either no ice, or but weak ice, formed over a large section of the river in the neighborhood of the Stony Brook and Fens basin outlets. Further, it is apparent that the great exposure to winds would prevent the formation of smooth ice for skating over most of the basin, and a proper surface could be secured and maintained, if at all, only by planing and scraping, as has had to be done at Jamaica Pond and Franklin Field.

6. The one recreative use of the lower river which has developed in a marked degree is bathing. In 1899 the city of Cambridge constructed an artificial beach at Captain's Island, and a locker house. In the summer of that year 20,000 persons used the beach for bathing, and over 60,000 in the ensuing summer. Within a mile above this point are half a dozen sewer overflows, and nearly an equal number within a mile below it; and while, with free passage for the great volume of comparatively pure sea water that daily flows and ebbs past the beach, sewage pollution of the water bathed in is reduced to a minimum, and the water itself is constantly renewed, with the salt water replaced by warmer, stagnant and polluted fresh water, I do not think that bathing would longer be either sanitary or agreeable.

7. In so far as river walls might hereafter be constructed, their cost would doubtless be reduced by maintaining a basin of constant height, since they need not then be carried materially below the standard water level. But in the project for the dam, the possibility is evidently contemplated that it may be found necessary to empty the basin periodically, in order to lessen its unfavorable effect upon the harbor channel, and special sluiceways are provided, "through which water may be very rapidly released from the basin on the falling tide to reinforce the tidal ebb current." Evidently, if walls were once constructed adapted to a basin level at 8 feet above low water, and the practice just mentioned should prove necessary, the walls would need to be rebuilt according to the present type. As I have elsewhere pointed out, however, river

* Twenty-sixth annual report of Board of Park Commissioners, page 21.

walls are not an essential to the improvement of the river banks, and this has been abundantly demonstrated in practice.

8. The question arises as to the extent to which a dam at Craigie bridge would prevent overflow of the marshes, and as to its effect in increasing the discharging capacities of sewers at high tide. Tide-marsh levels lie mainly between grades 10 and 11. I have elsewhere stated that less than one-fifth of the shore line of the proposed basin remains at marsh level, and this could be diked as at Captain's Island for a very moderate expenditure, so as to exclude tides from the meadows. Without dikes I do not think it is certain that the flooding of these lands could in extreme cases be prevented, even with a dam at Craigie bridge, and this statement is based upon somewhat detailed computations. It surely could not be prevented, under conditions of freshet and of tide that are perfectly possible, without the exercise of such foresight as would insure the emptying of the basin on the preceding ebb tide through every available opening in the dam, including the lock.

The depth to which the basin could be emptied on the ebb by such means would depend upon the level reached by the tide at low water on the harbor side of the dam. Mean low water at Boston is considered to be grade .64 referred to the city base. Normal or predicted low-water levels ranged, however, in 1901, all the way from grade —1.1 to grade +2.6 (diagram C *), and 42 times in the year were above grade +2. In some years low waters are predicted as high as grade +2.8. Severe wind storms and barometric disturbances affect the low-water level, however, in the same manner and to substantially the same extent that they do high-water levels. It thus happens that not infrequently low-tide level is from 2 to 3 feet higher than predicted, and that levels as high as grade 3, grade 4, and even above grade 5, are sometimes observed. In the two-years period from March 1, 1898, to March 1, 1900, the Metropolitan Sewer Commission's tide gauge at Deer Island recorded at least 29 low waters higher than grade 3, of which 9 were higher than grade 4, and 2 higher than grade 5. Abnormally high high water and abnormally high low water are both to be expected with easterly storms, at which times the river is also liable to be in flood.

Inasmuch as the basin level must be higher than the harbor in order that there should be any discharge at all from it, it is obvious that it could not fall as low as the tide, but even with every opening entirely free would halt at a level which, as nearly as I can determine, would be not less than about 6 inches above the low water of the accompanying tide. It might thus happen that the basin could not be drawn on the ebb below grade 5, or even much below grade 6; and under such circumstances its net capacity for storing the freshet flow that might come down the river in the ensuing seven or eight hours would become greatly curtailed.

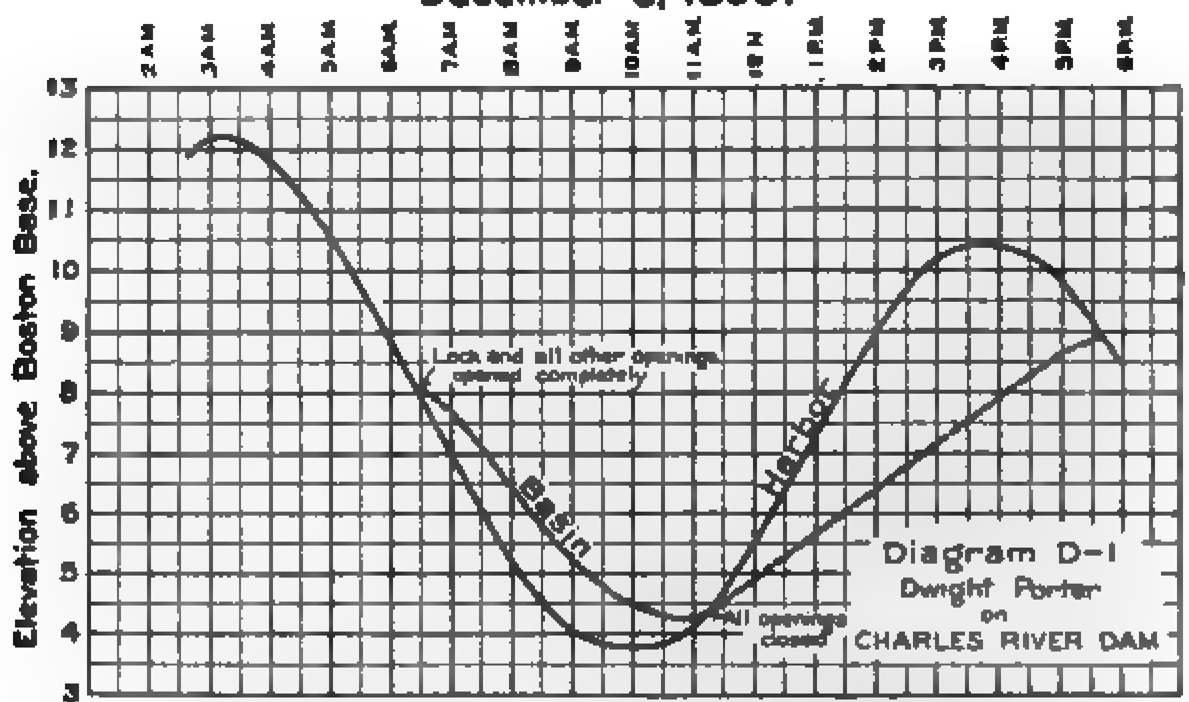
No accurate information is accessible as to the amount of fresh water discharged into the Charles River basin during extreme freshets. In the Joint Board report of 1894 Mr. Stearns estimated the flow over Watertown dam in the freshet of February, 1886, to have been 5,200 cubic feet per second, and the total into the proposed basin 6,000 cubic feet per second.

In 1886 a commission composed of James B. Francis, Eliot C. Clarke and Clemens Herschel, engineers of most distinguished ability, after a careful study of the case of Stony Brook, concluded that in the Feb-

* Diagram C not reproduced.

ruary freshet of that year the run-off from the water-shed had reached as high a rate as 1,500 cubic feet per second, although, being held back in sundry ways, it did not actually flow down the channel at so large a rate. They decided, however, that a future flow should be

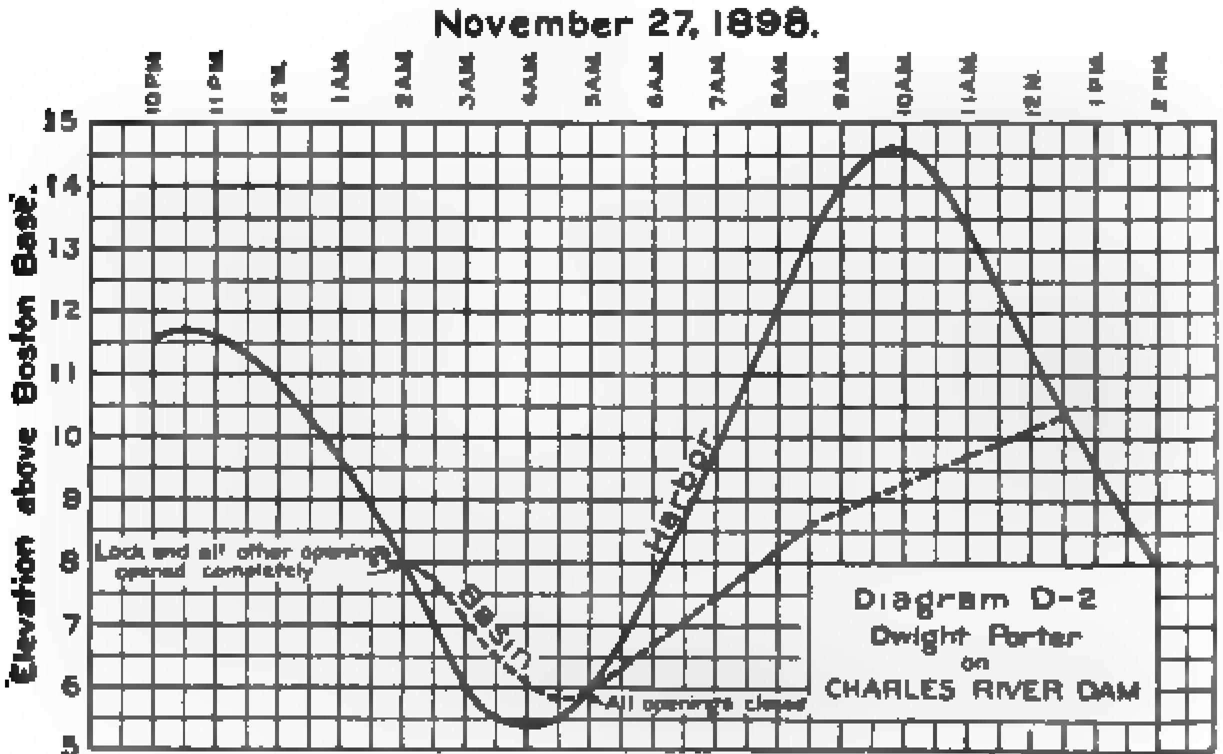
December 5, 1898.



Computed Curve of Variation in Proposed Basin,
assuming freshet inflow of 7000 cubic feet per second coincident with tides such as those of December 5 1898.

Photo Reduce to 3⅝ inches.

November 27, 1898.



Computed Curve of Variation in Proposed Basin,
assuming freshet inflow of 7,000 cubic feet per second coincident with tides such as those of November 27, 1898.

anticipated of 2,000, and even ultimately of 3,000, cubic feet per second, and in accordance with the former of these amounts designed the Stony Brook conduit, in favor of which they reported and which was afterwards built.

The evidence gathered by Mr. Stearns in 1894 indicated that the flow of the Charles had reached a maximum of 4,900 cubic feet per second in February, 1886, at the Waltham dam. Thence to Craigie bridge there is about 58 square miles of increase in drainage area, of which 13 square miles belong to Stony Brook. The remaining 45 square miles is in part highly developed, with much surface rendered artificially impervious to rain; and the balance is constantly and rapidly tending towards the same condition, as foreseen by Mr. Francis' commission in the case of Stony Brook. For this 45 square miles it would be moderate to assume a possible run-off of 40 cubic feet per second per square mile, — a rate not even as great as that reached by the Sudbury water-shed in the above freshet. A study of such information as is available regarding rainfall and stream flow in this vicinity in that freshet seems to me to show that Stony Brook, in common with the Sudbury, reached substantially its maximum rate of run-off about midnight of the 12th, or in the early morning of February 13, shortly after the end of the heaviest part of the rain; and that at the same time the flow of the Charles over the Waltham dam, while not at its maximum, was probably as great as 3,500 and perhaps as great as 4,000 cubic feet per second. On the whole, it seems to me that a total freshet flow into the basin of not less than 7,000 cubic feet per second should be anticipated. Mr. French, town engineer of Brookline, long familiar with the Charles and its water-shed, testified in 1894 that in his judgment 10,000 cubic feet per second would not be an excessive estimate of extreme freshet flow.

I have assumed, therefore, for the purpose of computation, a flow of 7,000 cubic feet per second, and that it might occur with a tide, not in any sense extreme, such as that registered at Deer Island Dec. 5, 1898, when a high water at grade 12.2 was succeeded by a low water at grade 3.8, and that by a high water at grade 10.4.

I have favored the basin in the following respects: by assuming that during the tide beginning the period in question it had been possible to keep the basin level down to grade 8, which is not certain; by assuming that at the earliest possible moment every water way in the dam, including the lock, was thrown wide open, and so maintained throughout the rest of the ebb; by assuming that the gate openings were all of effective dimensions given in Mr. Blake's paper, without reduction for gate fittings; by assuming coefficients of discharge determined from my own observations, and probably larger than those that would hold for the openings in the proposed dam; and by assuming the lock to be rectangular in section, instead of

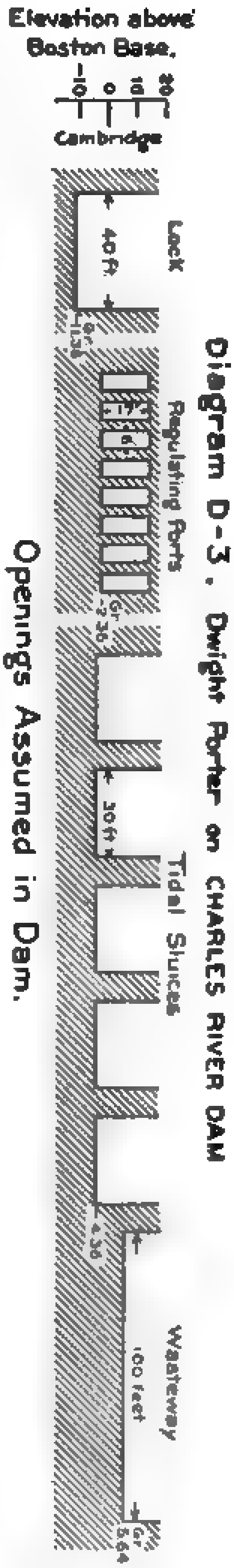
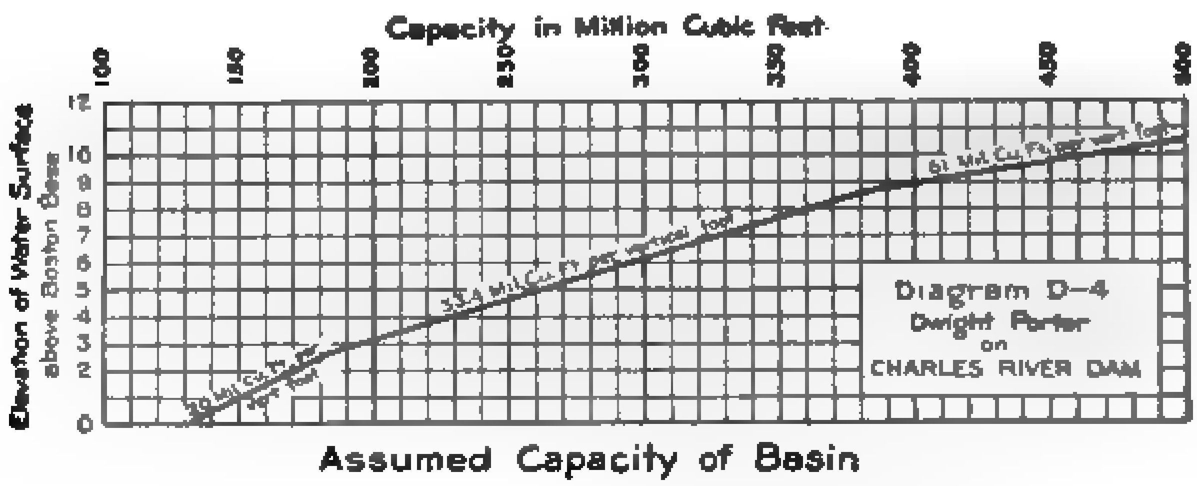


Diagram D-3. Dwight Porter on CHARLES RIVER DAM

Openings Assumed in Dam.

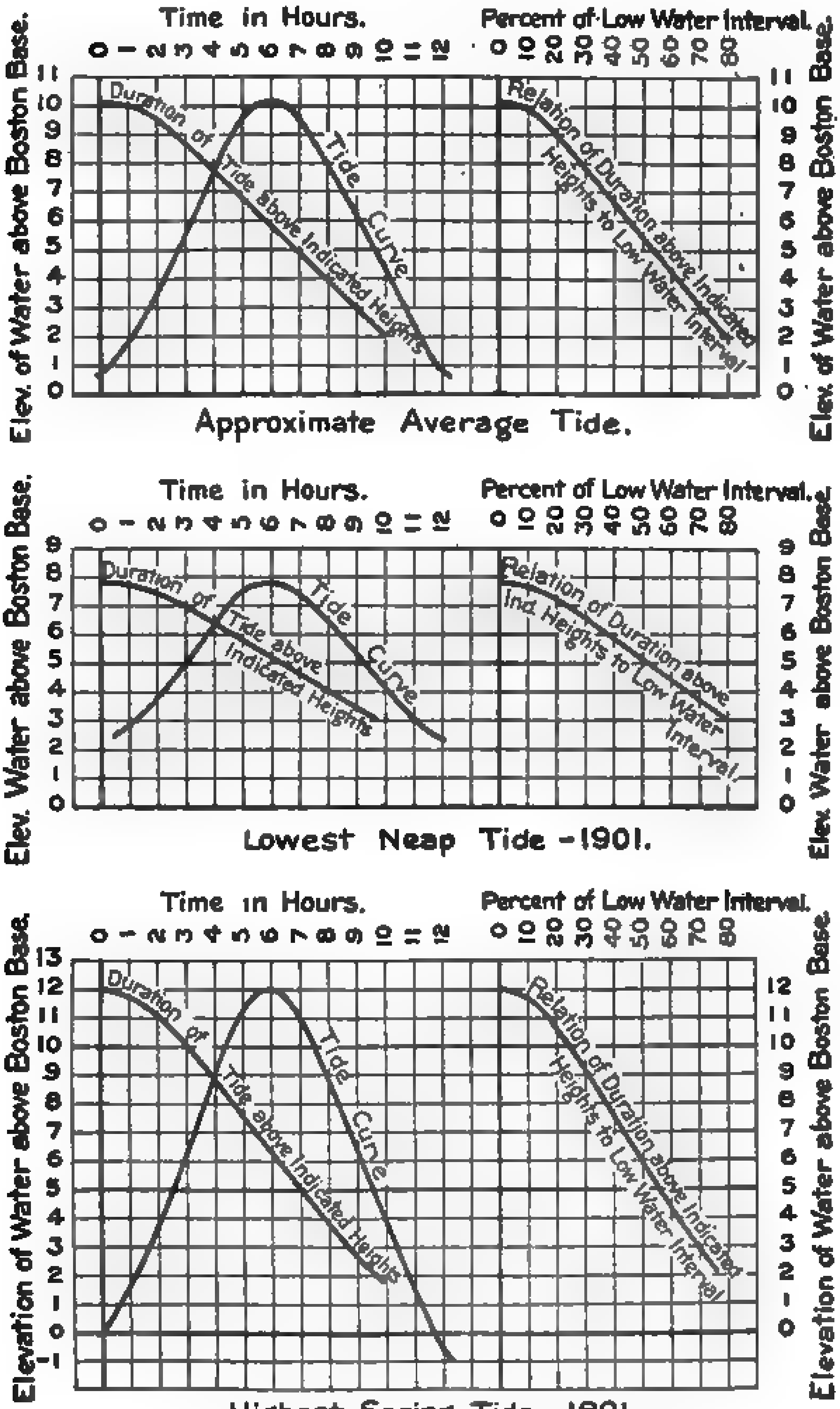
curved, with the bottom on the level of the lowest point of the proposed section. The values taken for the capacity of the basin at different levels are merely approximate. The simultaneous variations in level of harbor and basin are shown graphically on diagram D, from which it will be seen that the computation indicates a rise of basin to about grade 9. The same freshet discharge into the basin on a tide such as that of Nov. 27, 1898, would undoubtedly carry the level above grade 10, no matter how many or how large openings there might be in the dam. Considering, then, how little is known as to the actual flood volumes to be dealt with, and how little as to the velocities to be realized through such openings as are proposed for the dam, I conclude that, while overflow of the marshes is not probable, its complete avoidance is by no means certain.

As to the effect of a constant level upon the discharging capacities of tributary sewers, this may be said: of between 30 and 40 sewers discharging at times directly into the river, about a quarter have their outlets entirely above grade 8; about half the outlets are entirely below grade 8; and the remainder are partly above and partly below that level. If the basin could be kept always down to grade 8, then for about 30 per cent. of the time during the year, in which the tide now stands



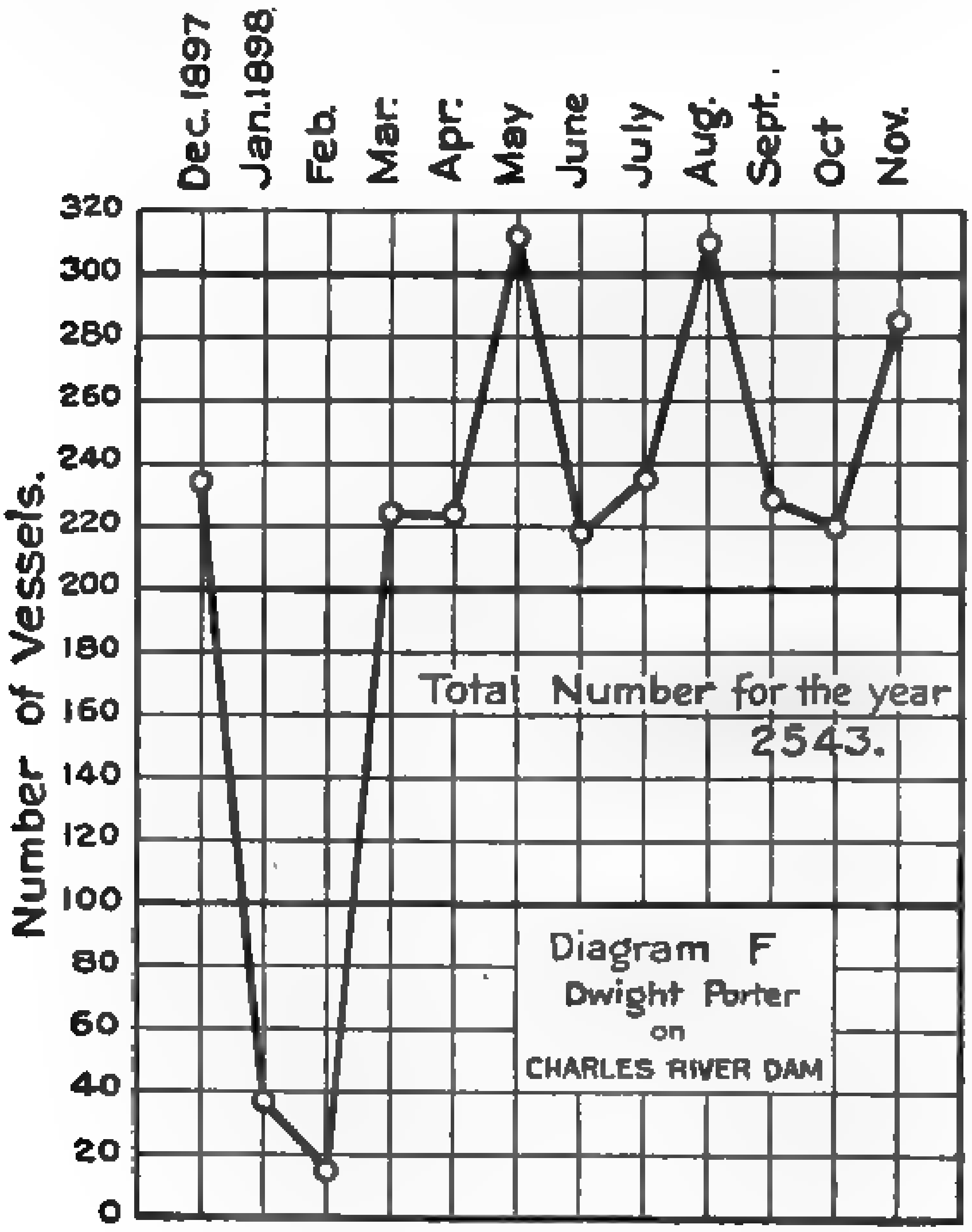
higher than that elevation, sewer outlets below grade 8 would be less deeply submerged than now, and their capacities would be increased, in the sense that they could discharge more water than now without becoming gorged in their upper courses, — or, to look at the matter in another way, could carry off the flow from exceptional rains with less backing up in connecting sewers and drains due to the height of the river. The other 50 per cent. of the sewers, whose outlets are either partly or wholly above grade 8, and yet not in most cases beyond the reach of high water, would be helped as to exceptional rains for varying proportions of the time, ranging from 30 per cent. down to nothing, according to the height of the outlet. I judge, however, that many of the sewers are now adequate for all requirements, and do not need increased capacity; and, inasmuch as the basin is likely to rise in times of the heaviest storms materially above grade 8, the advantage is correspondingly lessened. On the other hand, it is to be noticed that for about 70 per cent. of the whole time during the year, the river surface is now lower than grade 8 (see diagram E). Hence, for that proportion of the time, with a dam, there would be greater submergence than now for from one-half to three-quarters of the sewers, and the discharging capacities of these would be *reduced*, in the sense that gorging and set-back would occur with a less rain-

Diagram E, Dwight Porter on CHARLES RIVER DAM



Predicted Tide Curves

fall than now. As an example of what has been said may be cited the Binney Street sewer, in Cambridge. Computation indicates that, without entirely filling at the upper end the level portion of this sewer, extending back a quarter of a mile from the river, a discharge of 200 cubic feet per second can be carried with the river standing at



NUMBER OF VESSELS PASSED THROUGH DRAW OF WEST BOSTON BRIDGE — DECEMBER, 1897, TO NOVEMBER, 1898.

See page 292, Annual Reports to City Council of Cambridge for the year 1898.

grade 8; but that this increases to 300 cubic feet per second when the river sinks to grade 6, and 350 cubic feet per second when it sinks to grade 2.

9. It has been said that navigation of the river would be improved by a dam, since vessels could ascend at all times, and with a constant water level would always be afloat. It is plain that they could not enter the lock at such times as it might be required as a wasteway for drawing down the basin and providing storage room for freshet water

during the ensuing tide; and, if they could enter then, they would not find the water at grade 8, but lower.

Upon entering the basin, the change from salt to fresh water would result in an increase of draught of vessels in the ratio of the relative specific gravities of sea water and river water, or 1.028 to 1, amounting to 5 inches on a 15-foot draught. With a grade 8 level the depth available for vessels approaching wharves and passing over the shallower portions of the river would be reduced by the difference between grade 8 and existing high-water levels, or by about 2 feet on average tides and from 3 to 4 feet on spring tides.

In a fresh-water basin navigation would presumably be entirely suspended for two or three months, while now boats enter the basin during every month of the year. In 1897, vessels to the number of 2,418 passed through the draw of the West Boston bridge, and 2,543 in 1898 (see diagram F).*

10. It is intimated that the flood tides bring into the Charles River a large amount of impurities derived from the previous ebb and from the contributions of sundry other estuaries connected with the harbor, the implication seeming to be that the tidal flow is of little sanitary consequence to the river, and that its exclusion would be of no disadvantage. This is not in accordance with the views expressed by the State Board of Health in 1892,† when it found from its own examinations that, even in a neap tide, as far up as "North Harvard Street more than half the water was sea water, showing that even on the neap tide sea water is an important factor in maintaining the sanitary condition of the river, at times when the flow of fresh water is small, up to or beyond this point." The results of these examinations were set forth strikingly in a diagram, upon which the following comment was made in the report: "The albuminoid ammonia diagram, which is given as the best measure of the pollution of the river at different points, shows even more than the chlorine diagram the extent to which the river depends upon the free entrance of sea water for maintaining its sanitary condition. The relative amount of sewage entering the river between the different sampling places is indicated by black circles in the upper part of the diagram, the areas of these circles being proportionate to the amount of sewage. In two cases a very large amount of manufacturing waste is turned into the river, and this fact is indicated upon the diagram by an annular shaded space surrounding the black circle, and intended to indicate roughly the relative amount of pollution by those wastes. It will be observed that, although these circles show that by far the greatest amount of foul matter enters the river toward its mouth, yet the curves of albuminoid ammonia indicate that the water is in the most polluted condition near the upper end of the tidal portion, showing again, and in an emphatic way, the extent to which the lower portion of the river depends for its purification upon the cleansing action of the tide water."

These examinations were made before the north metropolitan sewerage system had been built, and when sewage from Cambridge, Somerville and Brighton was being constantly discharged into the river. Although the free ammonia in the water was relatively high, and pointed to previous sewage pollution, yet, so far as decomposable organic matter remaining at the time in the water was concerned, as measured by the albuminoid ammonia the examinations showed no greater proportion at Craigie bridge than has commonly been found in

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* Reports of Cambridge Bridge Commissioner.
† Annual report of Board, 1892, pages 285 *et seq.*

the fresh-water portion of the lower river, — at West Roxbury, for example.

With reference to floating débris, it is my impression, based upon observation while on the river, that as much originates along the shores of the river as in the harbor. If, however, the resultant movement is toward the basin, this material could easily be intercepted, in the main, by a light floating boom at one of the bridges.

11. I believe that a fresh-water basin maintained at an approximately constant level would frequently become offensive both to sight and to smell, — locally in the vicinity of the sewer outlets, and perhaps generally. I believe that this would result from the comparatively stagnant condition of the proposed basin during dry weather, from the growth and decay of vegetation and of animal life fostered by the warm and impure water, and directly from the discharge of sewage into the river. In the Joint Board report of 1894 it was stated that it would require nearly three months (eighty-two days) to renew the contents of the basin fron the dry-weather flow of the river alone, and since that time the capacity has been increased nearly 20 per cent. by dredging. If that flow were uniform past a cross-section in the vicinity of Harvard bridge, the current would amount to but 5 or 6 feet an hour. To remedy the tendency to stagnation, it is apparently proposed to withdraw part of the water in the basin from time to time through the dam, and replace it by sea water admitted at the same place. It is considered that through submerged sluiceways at the dam sea water can be injected so as to remain as a distinct bottom layer in the basin, and that similarly the lower water can be removed as a distinct layer. The assumption presumably is that a layer can be thus removed and replaced at will substantially throughout the basin, without disturbing the upper water, but for such assumption I doubt that sufficient justification can be found. My own judgment is that the effect of either admission or withdrawal would be confined to the down-stream portion of the basin. The operations of filling and drawing could not take place simultaneously, and a fluctuating basin would be the necessary consequence, the range depending upon the amount of change found necessary in the water. The Fens basin receives, some of the time, relatively no more organic matter than the Charles brings over the Watertown dam; yet it is found essential to change its water in large measure at every tide, by the admission of sea water via the Muddy River conduit and the Brookline Avenue gate-house. This necessity is no doubt largely due to the accumulation of sewage mud in the basin, but such accumulations would also be possible in the proposed basin in the Charles. The automatic gates for flushing the Fens basin were built in 1898, and sea water equivalent to a depth of 1 foot over the 30 acres of the basin was introduced at every tide. In spite of this, the superintendent of the park department reported two years later that the condition of the water in the Fens had not much improved, and that the flushing gates had therefore been enlarged so as to admit an increased volume of sea water. The equivalent of a depth of 18 inches is now introduced at every tide, in warm weather, and this is considered the limit of allowable fluctuations in the basin, on account of possible injury to plantations along the banks and the exposure of mud flats if it be increased. In this case the water admitted is compelled to traverse the whole length of the comparatively narrow basin, while in the Charles the water for purifying would be admitted and removed at the same point, and could not traverse the basin. Experience with water stored in the various ponds and reservoirs of this State has amply demonstrated that disagreeable odors from impounded

surface water are extremely common, and that they originate both with numerous living forms of plant and animal life of minute size and from the destruction of such life; and that, inasmuch as these forms cannot live without food supply, their development is largely dependent upon the presence of organic pollution in the water.

Eight sewers for surface drainage only, one or two of them serving as large a district as 50 or 75 acres each, discharge directly into the lower Charles; but at present the most serious pollution comes from the overflows of the various combined sewers of Boston, Cambridge and Brookline, connected with the main drainage or the metropolitan intercepting sewers. There are about 15 such overflow openings on the north side of the river between Craigie bridge and the Watertown dam, about the same number on the south side, and about 30 along the course of Stony Brook which are thus indirectly tributary to the Charles. Muddy River also receives sewage overflow from the Brookline main sewer during storms, and conveys it to the Charles through the Muddy River conduit. Altogether there are some 60 points where house sewage overflows at times to the river, two-thirds of which are below Cottage Farm.

The discharge from these overflows is often extremely offensive to the sight and distinctly so to the smell, as I can testify from repeated observation, and is wholly out of keeping with what would be expected in the central feature of a "water park." It is frequently characterized by the presence of a large amount of floating fæcal matter, toilet paper, matches, fruit skins and other waste. From the Berkeley Street overflow I have observed a strong flow of sewage of almost inky blackness, the color presumably due to putrefaction within the sewer since the last preceding overflow. A great deal of fine silt from the streets, which has passed through the catch-basins, also comes along at such times, and may be seen to discolor the river several hundred feet out from the sea wall. Unless carried off by a current or driven away by wind, much of the sewage scum would remain floating indefinitely about the shore in the vicinity of the sewer outlets, giving off the sickening odor of grease which is characteristic of sewage-polluted streams, and which I have myself noticed at times during the past winter at the Fens basin near the Stony Brook outlet. The heavier matter in the sewage would sink, in slack water, and thus form deposits from which putrefaction would go on continuously thereafter. During the past winter I have seen gas bubbling up from such deposits all over the open channel in which the Stony Brook conduit terminates, and have been informed that in summer the action is very marked there and in the adjacent portion of the Fens basin.

But little authentic information is available as to the actual frequency or extent of sewage overflows into the Charles. Storm overflow outlets were first introduced in Boston in connection with the main drainage intercepting system, completed about 1884. That system was planned to care ultimately for the sewage proper of a population of 800,000, at the average rate of 75 gallons per head per twenty-four hours, and at a maximum rate 50 per cent. greater; together with rainfall from the tributary area at a rate equivalent to ¼ inch per twenty-four hours, a mere drizzle, expected to provide only for the "first wash" in general and for a larger proportion of the rain falling on certain low areas. A pumping plant was installed, of a total nominal capacity of 100,000,000 gallons per twenty-four hours, but which had a maximum capacity possibly nearly equal to that of this intercepting system as a whole, which is placed at about 150,000,000 gallons per twenty-four hours. Manifestly, at the start, before the population had increased to the

limit contemplated in the design, there was opportunity in the system to take much more surface water than the nominal amount assumed in the design. Nevertheless, it appears from Mr. Eliot Clarke's report* on the system that there were sewer overflows at twenty-four different times in the first year after its completion. When these works were put in operation, in 1884, the population effectively tributary did not probably exceed 300,000. The area tributary in 1900 did not contain more than about 600,000 population. This was 200,000 short of the originally assumed number; yet, in speaking of the capacity of this system in its report of 1900 upon the "Discharge of Sewage into Boston Harbor" (page 19), the State Board of Health, through its engineer, said: "The quantity of rain water that can be received from tributary districts provided with combined sewers is already less than was intended to be received when the works were constructed; and, as the quantity of the ordinary flow of sewage in the main drainage and tributary systems increases with the growth of population in the districts which these systems now serve, the capacity of the main drainage system for removing storm water, except from the four districts referred to, will decrease, and, unless some relief is provided, overflows will occur with smaller rains and thaws and increase in frequency and duration, thus tending to defeat the object for which the works were built, viz., to prevent the pollution of the waters about the city." The relief referred to is expected to be afforded by the high-level sewer now being built; but the fact remains that when the population has reached figure 200,000, or 25 per cent. less than originally assumed, the capacity of the system for taking rain water, upon which capacity the extent of sewage overflow is dependent, has become reduced below what was supposed to be available with a population of 800,000.

The difficulty in forecasting the amount of domestic sewage to be cared for in the future, dependent as it is both upon the water consumption per individual and upon the extent and density of settlement, is illustrated by the facts that, in the case just cited, 75 gallons per person per twenty-four hours was thought to be a sufficient average allowance for the future; that in 1894, in careful studies for the Boston metropolitan district, 100 gallons was thought to be a sufficient assumption as to water consumption for thirty years to come, and yet the actual consumption increased from 83 gallons in 1893 to 94 gallons in 1897; and that in 1900 the engineer of the State Board of Health, in the report above referred to (page 21), in considering the amount of water to enter the sewers from public water supplies in the main drainage and connecting districts, predicted as follows: "In the district under consideration, judging from past records and present tendencies, the indications are that the increase in consumption of water will continue indefinitely, and that it will reach 200 gallons within the next forty years."

As previously stated, the main drainage works were put in operation in 1884. The new Stony Brook conduit, sometimes referred to as "Commissioners' channel," was first used about five years later, in 1889; yet by 1897 it had delivered silt and sewage to the Fens basin, presumably from sewer overflows, to the extent of forming a deposit 3½ feet deep, extending from the conduit outlet to Agassiz bridge. I am informed that in 1897 the deposit was estimated to amount to 30,000 cubic yards of mud and sewage, and this has steadily augmented since, except as a part was removed in 1898. The accumulation covers

* Boston Main Drainage, page 94.

5 or 6 acres. In the report of the Boston Park Commissioners, January, 1898, page 15, the superintendent said: "This deposit is very offensive when the water is lowered in the Fens, and is probably a menace to health." In the report of January, 1900, page 24, the engineer of the Board stated as follows: "The automatic gate put in last year at the Riverway gate-house has done excellent service in preventing the water in the Fens from becoming foul; but the sewers connected with Stony Brook frequently overflow, and the grease from the sewage thus turned into the Fens is being continually deposited on the shores of the pond. In summer the flow of the brook is so small that the water in the lower part of Commissioners' channel becomes stagnant, and often very foul, before it is forced into the Fens by the occasional rains. The amount stored in Commissioners' channel when the water in the Fens is at elevation 8, its normal height, is about 600,000 cubic feet, which is equivalent to 2 acres of water 7 feet deep." He again reported in January, 1901: * "To improve the condition of the Fens pond, the overflow at Beacon Street has been lowered to grade 7, and changes have been made in the gates at the Muddy River gate-house, by which a much larger volume of sea water can be turned into the pond. A rise and fall of several feet during each tide can easily be maintained in the pond; but to avoid injuring the plantations and exposing the unsightly banks, it is thought best to limit the fluctuations caused by the tides to 18 inches at each tide. This changes all the water in the Fens pond once in two and one-half days. That such frequent changing of the water is necessary to prevent the pond from becoming offensive is a good indication of its present condition, and shows the importance of preventing its further pollution. The deposit of foul mud and sewage that is the principal cause of the unsatisfactory condition of the pond covers an area of about 6 acres, to a depth of from 1 to 4 feet. It was brought down by Stony Brook, which receives a large amount of detritus from the streets and the storm overflow from many sewers. All of this is turned into the Fens pond, and nearly all of the solid matter falls to the bottom before it reaches Agassiz bridge. This deposit is increasing in quantity, and will continue to increase until the dirtiest part of the flow of the brook is kept out of the pond. Owing to the increasing population and to new connections with the sewers, the pollution of the brook is increasing, and there should be no delay in building the short section of conduit necessary to divert this part of the flow from the Fens pond, and carry it directly to the Charles River." The Fens basin, of 30 acres, is an object lesson regarding a basin such as is proposed for the Charles. It may be said that such deposits as might form in the Charles *should be* at once removed by dredging; but it is unsafe to assume that they *would be*, in view of the fact that while as early as January, 1898, the deposit in the Fens basin was brought to public attention as a probable menace to health, only about one-half was subsequently removed, and new deposition has steadily gone on since.

The automatic records obtained by the city engineer of Cambridge, from instruments attached to certain regulators and tide gates upon the sewers of that city, apparently afford the only direct evidence as to the frequency or duration of sewage overflows into the Charles River. The north metropolitan intercepting sewer system, with which the Cambridge sewers are connected, went into operation in 1895 or 1896. Within four years thereafter the Binney Street sewer regulator was closed in a single year 73 times, covering about 7 per cent. of the

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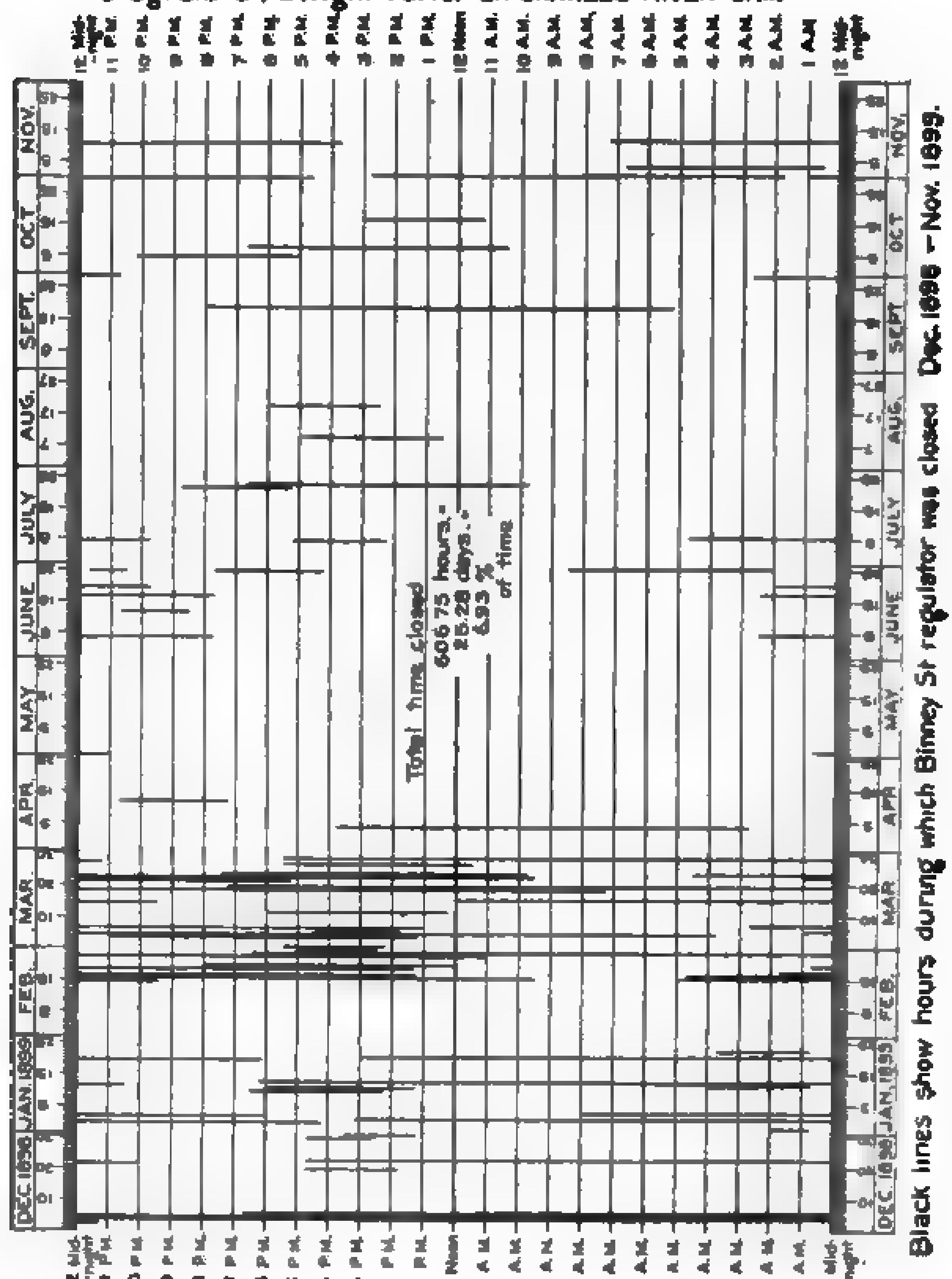
* Twenty-sixth annual report, page 22.

whole time, or the equivalent of about 25 days during the year. In other words, for that length of time the metropolitan intercepter rejected the sewage brought to it by the Binney Street sewer, and a large proportion was necessarily discharged through the old outlet into

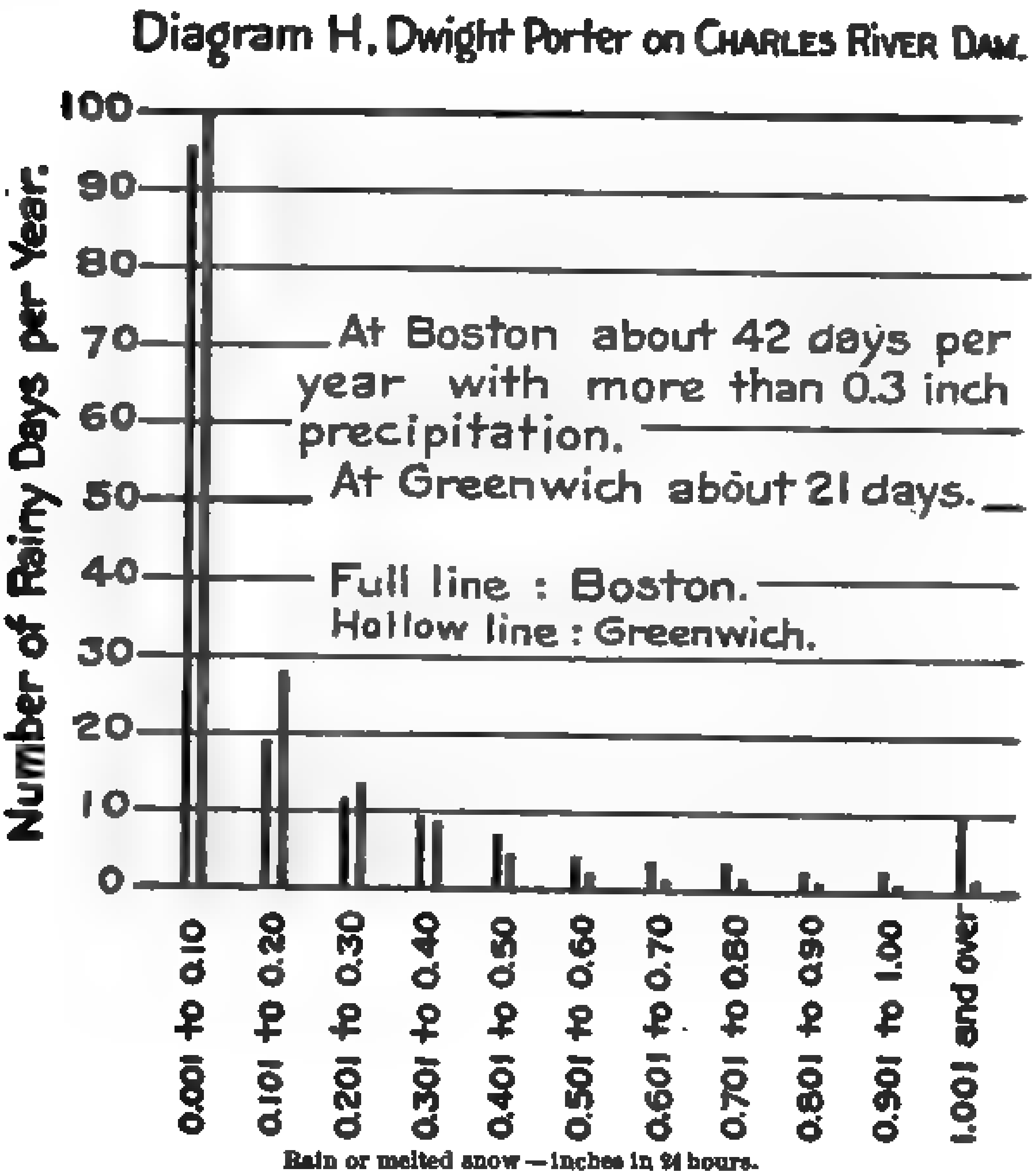
Diagram G, Dwight Porter on CHARLES RIVER DAM



the Charles River basin. This was during a year in which the total rainfall, the total number of rainy days, and the number of rainy days with more than .30 inch of rain, were all less than the average. Diagram G, on which the results of the regulator records are displayed graphically, shows that the regulator was closed at intervals during

every month of the year in question, though mainly in winter and spring, and for continuous periods ranging from a quarter of an hour to 67½ hours each. Overflows occurred frequently on days during which there was no rainfall, being then due to the thawing of snow.

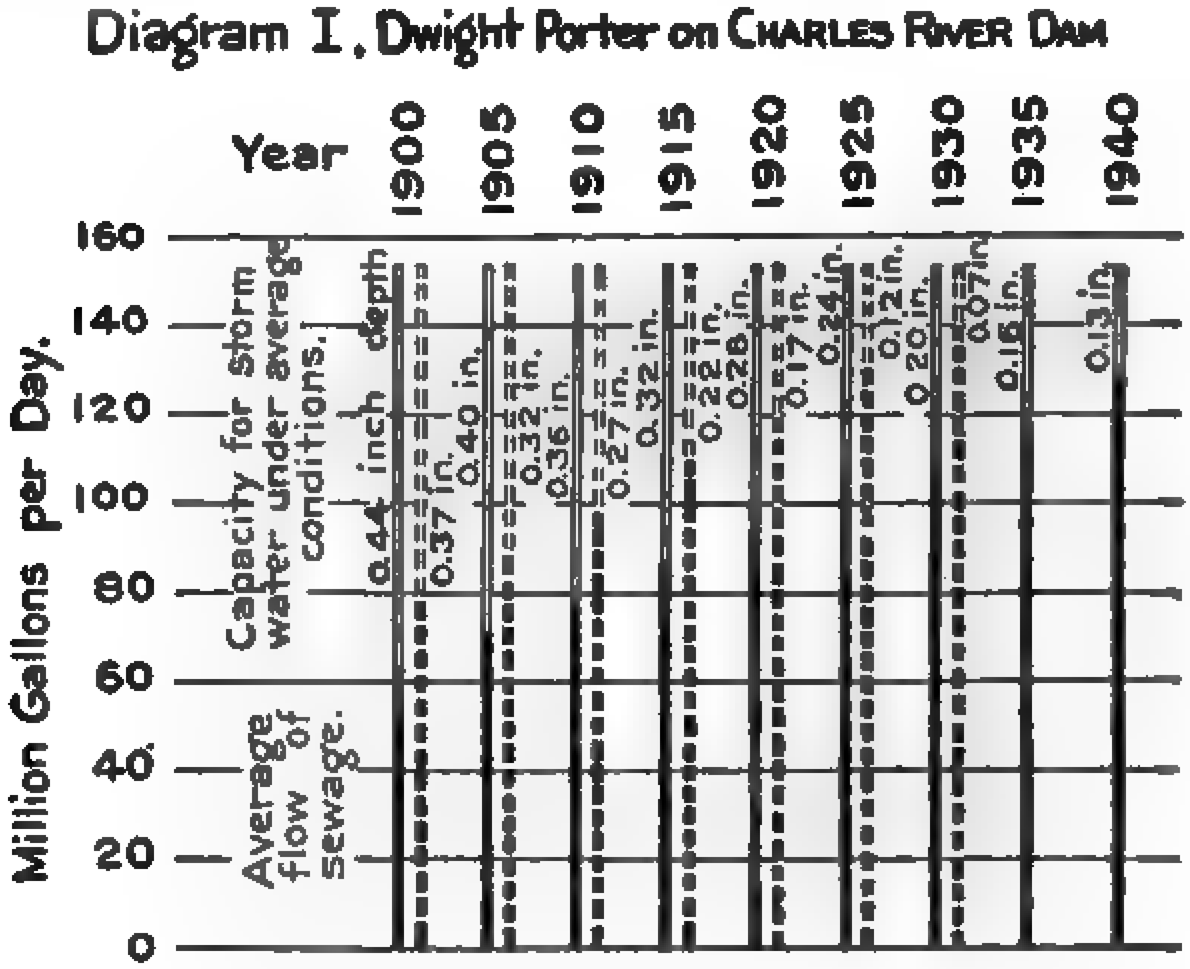
The Boston main drainage system is modelled substantially after that of London in the matter of intercepting sewers, nominal provision for rainfall (¼ inch per twenty-four hours in each case), and sewage overflows into the Charles and Thames, respectively. The London ex-



RAINY DAYS IN BOSTON, 1892-1901; IN GREENWICH, 1847-57, 1880-90.

perience with overflows is, therefore, of some value in comparison. W. S. Crimp, formerly district engineer to the London County Council, says, in "Sewage Disposal Works," page 151, in speaking of the London system: "With the assistance of Mr. Glaisher's table, the authors of the report of 1857 estimated that overflows into the Thames would occur on 12½ days per annum, and that 95 per cent. of the total volume of house, surface and subsoil drainage would be carried to the outfalls, the remaining 5 per cent. escaping into the river by means of the storm overflows;" and further, on page 152: "When the author

had charge of the main drainage works on the north of the Thames (1890–93), he found that discharges occurred on about 48 days per annum, and that, on an average, rainfalls of .13 inch and upwards per diem caused an overflow, although sometimes a fall of .25 inch in twenty-four hours failed to do so." It should be noticed in this connection that the average annual rainfall at London is only about half that at Boston (23.7 inches, against 47 inches); and that, while in London the average number of days per year with very light rain (less than .30 inch in twenty-four hours) is slightly greater than here, the number with the larger rainfalls, which are most certain to cause storm overflows, is only one-half as great (see diagram H). Moreover, I judge that the frequency of overflows due to melting snow must be much greater here than there. Other things equal, therefore, it would



Boston Main Drainage System after Completion of High-level Sewer.

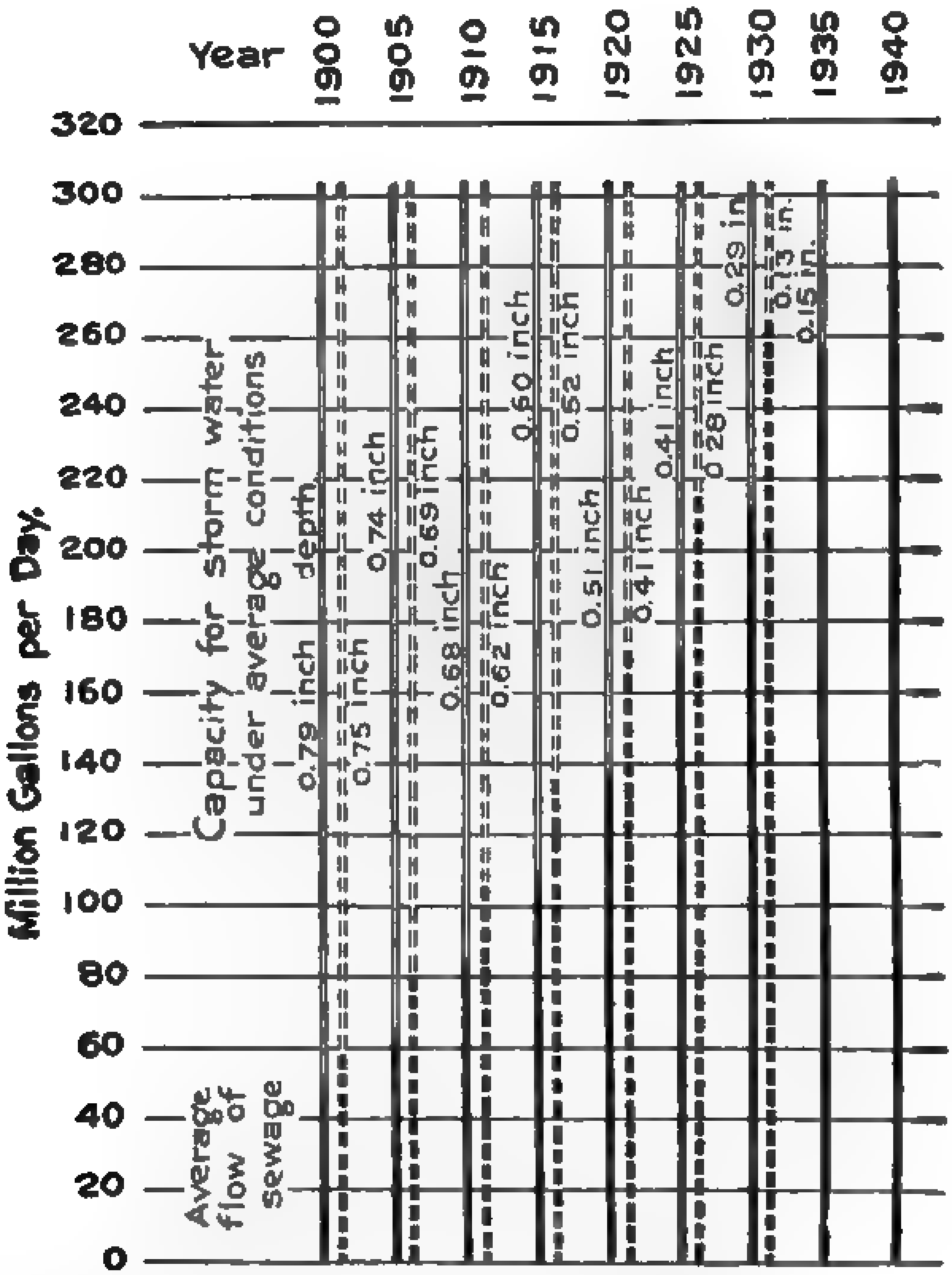
Full lines show average capacities for sewage proper and storm water as estimated in 1900 by State Board of Health (see report upon the discharge of sewage into Boston harbor, p. 67).
Broken lines show corresponding quantities at times when the flow of sewage proper, which is itself variable, is 25 per cent. in excess of average.

be fair to expect a materially larger number and longer duration of overflows from the Boston system than from the London. In the case of London · "The excessive volumes due to rain are allowed to escape into the river by means of 48 storm overflows; while, for the relief of certain low-lying districts, there are 4 auxiliary pumping stations for the purpose of lifting the storm water when the overflows are closed by high tides." With regard to these means of disposing of the storm waters, in their report the Royal Commission on Metropolitan Sewage Discharge, 1884, observed: * "The weakest points of the

* See "Sewage Disposal Works," pages 53, 54.

present system are: the necessity for a large provision of storm outlets; and the discharge of the sewage in its natural crude state;" and

Diagram J. Dwight Porter on Charles River Dam.



Capacity of High-level Sewer.

Full lines show average capacities for sewage proper and storm water as estimated in 1900 by State Board of Health (see report upon the discharge of sewage into Boston harbor, p. 65).

Broken lines show corresponding quantities at times when the flow of sewage proper, which is itself variable, is 25 per cent. in excess of average.

also: "We are of opinion that the discharges of sewage from the storm overflows, within the metropolitan area, are frequent and considerable, and that they are occasionally of very offensive character."

As nearly as I can ascertain, approximately the following populations now nominally contribute to sewer overflows into the Charles River above Craigie bridge: —

Boston, between Massachusetts Avenue and Cambridge Street,	37,500
Stony Brook basin,	109,600
Brookline,	16,000
Brighton,	12,500
Cambridge,	75,200
Newton, via Charles River valley sewer,	22,100
Watertown, via Charles River valley sewer,	6,500
Waltham, via Charles River valley sewer,	20,500
Total,	299,900

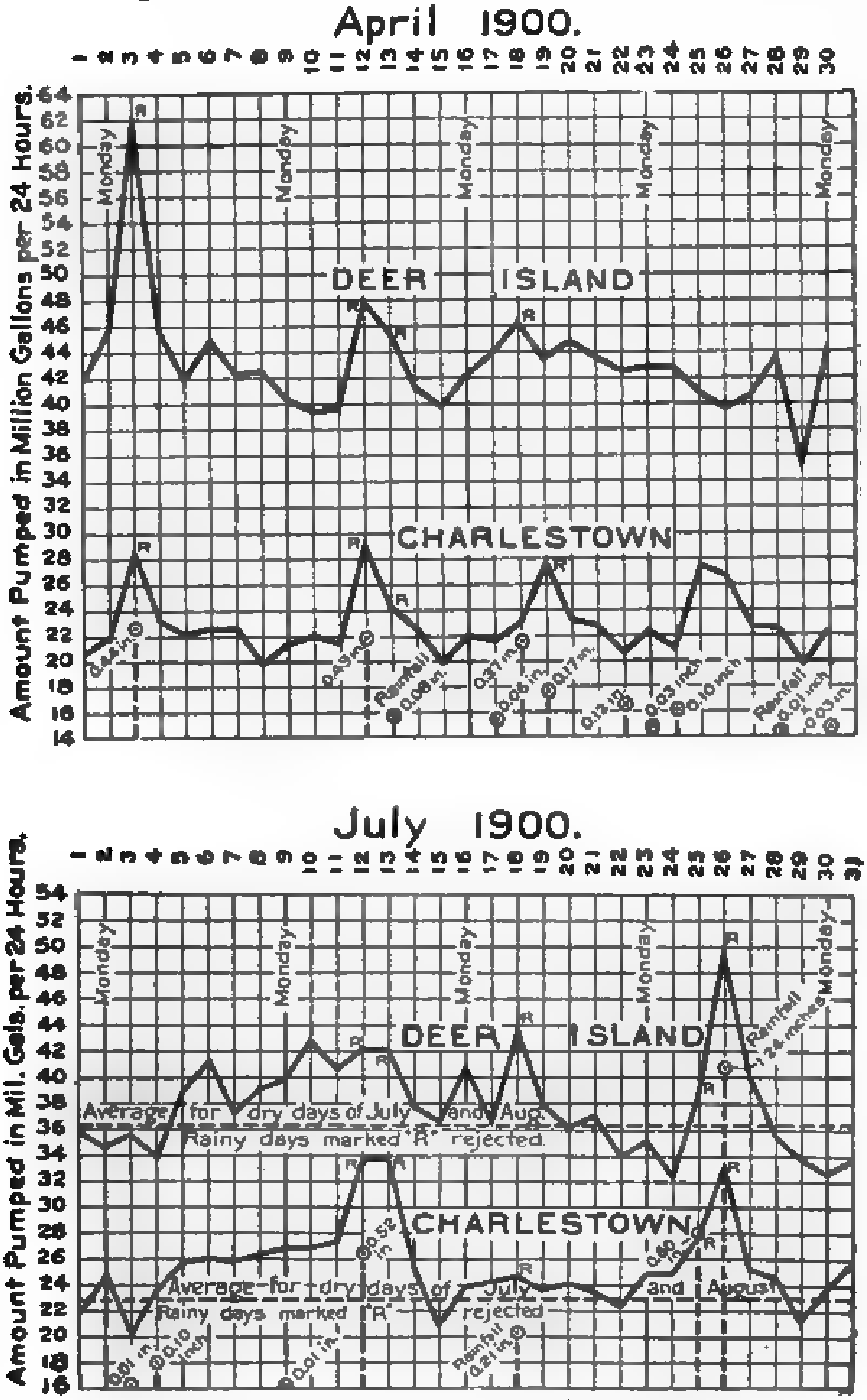
If the proportion of time during which overflows occur be taken at 7 per cent. only, as observed at Cambridge, the house sewage going to the river during the year is equivalent in amount to the constant discharge from a population of about 21,000 persons.

Supposing that, with the completion of the high-level intercepting sewer, the house sewage discharge were for the present entirely eliminated for all the above districts except Boston below Massachusetts Avenue, and Cambridge, there would remain a present tributary population of about 113,000, and the discharge from this for 7 per cent. only of the time would correspond in amount to the constant discharge from a population of nearly 8,000. This is likely to increase by as much as 50 per cent. within the next fifteen years, from the natural growth of population in these districts.

It has been pointed out by others that with the completion of the high-level sewer and the cutting off of the Charles River valley sewer from the Boston main drainage system, the capacity of the latter for receiving surface water and thereby preventing overflow will be much increased; and the State Board of Health has published tables showing the estimated capacity for storm water of both the main drainage system and the high-level sewer at successive five-year intervals up to 1940,* the results of which are graphically shown on diagrams I and J, accompanying this paper. A wrong impression may be drawn from these tables, however, unless it is kept in mind that they deal with averages, and that the quantity of sewage proper flowing in the sewers is subject to pretty regular and considerable variations. It is usually assumed that the maximum rate of flow of house sewage may exceed the average rate, taken say for a year, by from 50 to 75 per cent., even for rather large sewers. A limited study of the pumpage records of the Charlestown pumping station, through which part of the Cambridge sewage passes on its way to Deer Island, illustrated on diagrams K and L, indicates that even for the large intercepting sewers of the metropolitan system the rate of dry-weather sewage flow may frequently exceed the average rate of the same by at least 25 per cent. If the excess be no more than 25 per cent., it will result, if the estimates of the State Board of Health are correct, that, even with the Charles River valley sewer cut off, within about ten years from the present time the capacity of the main drainage system for taking rain water will frequently be less than the .25 inch per twenty-four hours for which it was planned, and sewage overflows will be correspondingly frequent. Similarly, the capacity of the high-level sewer for rain water, at times of the larger flow of house sewage, will have been reduced below .25 inch per twenty-four hours by about 1925. If the percentage variation in flow be taken higher than 25, the periods alluded to will be correspondingly shortened.

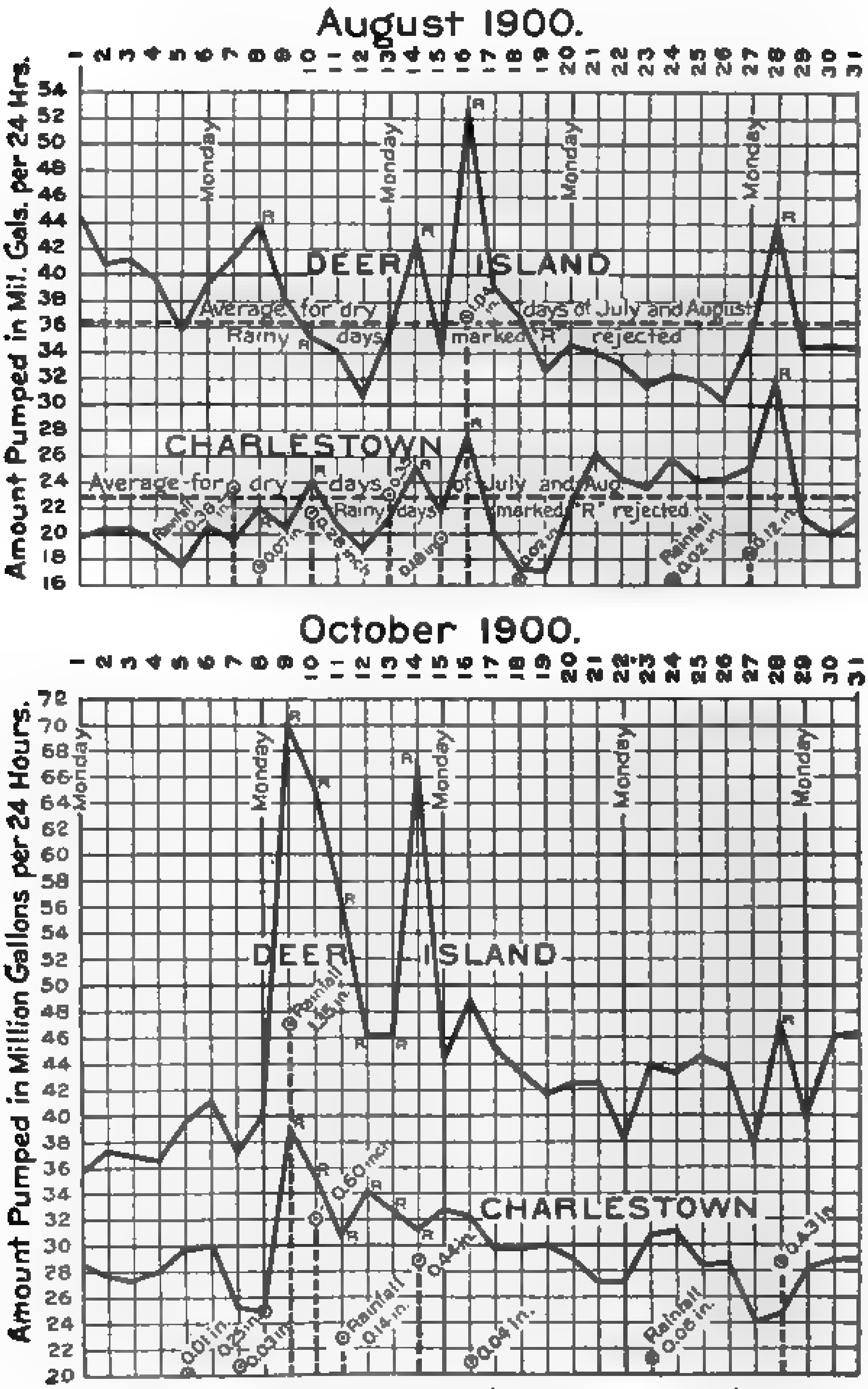
* "Discharge of Sewage into Boston Harbor," pages 65, 67.

Diagram K-1, Dwight Porter on CHARLES RIVER DAM.



Daily Pumpage Record for April and July 1900
of Charlestown and Deer Island Pumping Stations
of Metropolitan Sewerage Works.

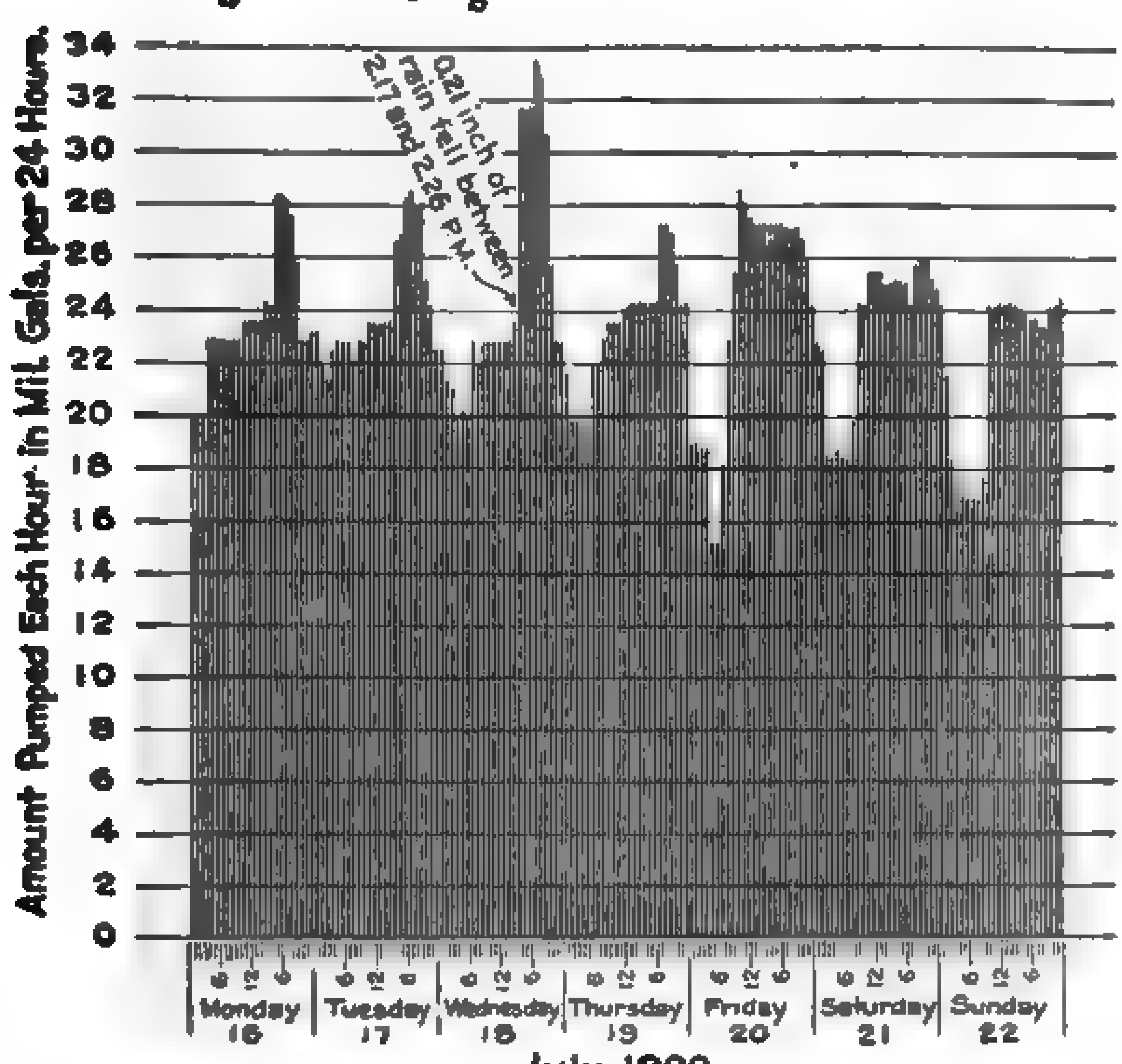
Diagram K-2. Dwight Porter on CHARLES RIVER DAM



Daily Pumpage Record for August and October 1900 of Charlestown and Deer Island Pumping Stations of Metropolitan Sewerage Works.

It has been further stated in testimony that the tendency in new sewer construction in the district under consideration is toward the separation of house and manufacturing sewage, on the one hand, from storm water, on the other hand, and their removal in distinct lines of sewers. The former will be received into the intercepting sewers, and the latter will presumably go to the river. The tendency to overflows of house sewage is thus to be relieved, and the implication appears to be that the fouling of the river will be done away with. It is a serious mistake, however, to attribute the polluting effect of "combined" sewage to that portion alone which originates within the houses; for the street surfaces contribute, through the catch-basins, a

Diagram L., Dwight Porter on Charles River Dam



Hourly Pumpage Rates at Charlestown Pumping Sta. of Metropolitan Sewerage Works, July 16th to 22nd, 1900.

large amount of organic matter, just as capable as human excreta of producing subsequent offence. In proportion as the separate system is adopted here for sewers, the house sewage kept from the Charles by preventing storm overflows will be replaced by street wash run directly into the river through the storm sewers. Dr. Samuel Rideal of London, in his work on "Sewage," says (page 6): "Street cleansing . . . results in a semi-fluid mixture, which often constitutes an important feature of the sewage. It contains a complex dust, abraded clothing and

wood, castings and emanations of men and animals, and particles of soot, iron, earth and stone, and is usually worse in character, especially from wood pavements, than an average sewage."

The question of the changing of the London sewerage system from the combined to the separate has been more or less discussed. W. S. Crimp, M. Inst. C. E., previously quoted, has this to say upon the matter, as related to the sewage derived from the streets, in discussing sources of river pollution: * "Another class of pollution is the drainage from street surfaces, which in towns with considerable vehicular traffic may be as impure as sewage. Table I (reproduced below) shows the composition of London street water, during wet weather, taken as it flowed into the sewers. It will be observed upon referring to the table that this liquid is highly charged with polluting matters, and, whilst it must not be inferred that the drainage from suburban roads with little vehicular traffic is as impure, the advocates of the separate system should attentively study this aspect of the question before insisting upon its adoption, irrespective of the conditions obtaining. Then there is the liquid, remaining after rain, in the street gullies, which in dry weather rapidly putrefies and becomes most offensive. This foul liquid is displaced on the advent of a shower of rain, and it should in many cases be purified before being admitted into a stream."

TABLE I. *Composition of Liquid flowing from London Street Surfaces, 1892 and 1893.* ("*Thoroughfares with much vehicular traffic.*")

[In parts per 100,000.]

COMPOSITION.	SAMPLES ANALYZED BY J. W. DIBDIN, F. C. S., "TAKEN SOON AFTER THE COMMENCEMENT OF RAIN."		SAMPLES ANALYZED BY MIDGLEY TAYLOR, F. C. S., "TAKEN AFTER RAIN HAD BEEN FALLING SOMEWHAT HEAVILY FOR TWO HOURS."	
	Wood Pavement.	Macadam.	Wood Pavement.	Asphalt.
Appearance,	Dark color.	Slate color.	Very dark.	Dark.
Odor,	Strong urine.	Urine.	Strong urine.	Faint.
Chlorine,	54.00	24.40	2.43	2.57
Free ammonia,	6.89	3.54	5.67	3.66
Albuminoid ammonia,	4.25	2.48	4.24	1.05
Suspended matter,	1,064.00	2,098.30	328.60	108.30
Dissolved solids,	579.20	217.20	60.46	18.80

The average composition of sewage experimented upon at the Lawrence Experiment Station, in this State, from 1888 to 1891, is given as follows: † —

	Parts per 100,000.
Chlorine,	5.73
Free ammonia,	1.86
Albuminoid ammonia,	.66

A comparison of the figures given will show that the London street wash contained relatively from more than one and one-half to six and one-half times as much albuminoid ammonia as Lawrence sewage, and from nearly two to nearly four times as much free ammonia.

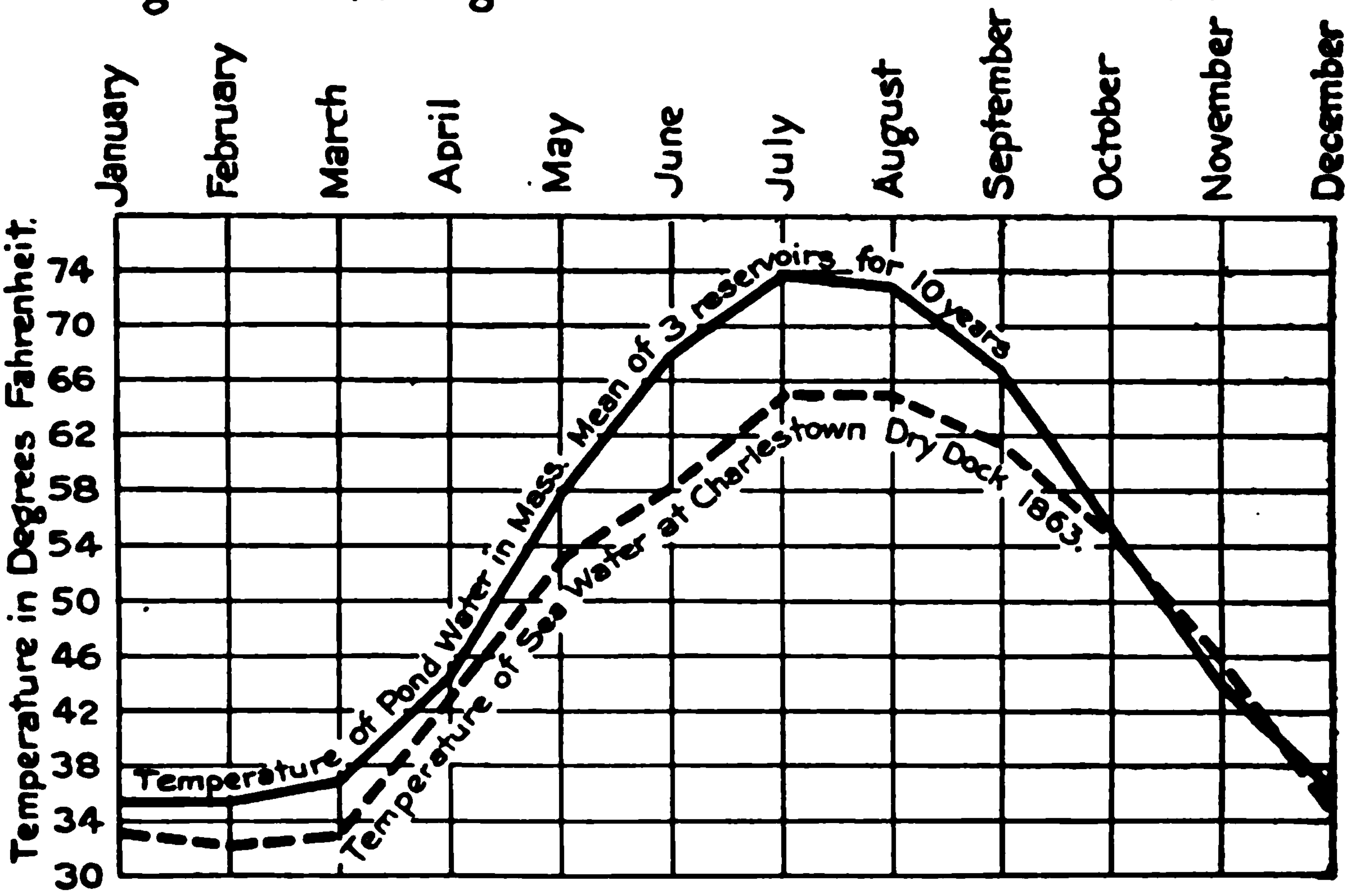
It is said that the volume of fresh water brought down by the Charles is sufficiently large to dilute, beyond the point of giving offence, any

* "Sewage Disposal Works," 1894, page 8.

† Rafter and Baker's "Sewage Disposal in the United States," page 152.

sewage likely to be discharged into the proposed basin; and an elaborate computation has been made by Mr. Blake, to show the probable varying degree of purity of the water in the basin during the year. It is assumed in this that a flow of 10 cubic feet per second of river water per 1,000 persons is adequate dilution to prevent nuisance. Regarding this it should be remembered that the proper assignment of any permissible limit of pollution is a matter of considerable uncertainty; but accepting the ratio stated above as being warranted, the important conditions to be observed in applying it are: that the diluting water itself be practically pure; that the sewage shall be mixed with it with substantial uniformity; and that the mixture shall promptly flow away. Neither of these conditions would be fulfilled in the proposed basin. The diluting water coming into it would be far from pure; the sewage would enter a relatively stagnant pond, in which it would be very im-

Diagram M, Dwight Porter on CHARLES RIVER DAM



Comparison of Temperatures, Sea Water and Reservoir Water.

perfectly diffused, and from which, in some seasons, it could not escape, except through decomposition, for weeks or even months. In connection with the table of permissible pollution, prepared by Mr. F. P. Stearns, as engineer of the Board of Health,* he himself says: "All of the foregoing relates to the pollution of the water itself, as if the sewage emptied into a stream of unvarying volume, flowing with sufficient rapidity to prevent deposits. If, instead, the sewage is turned into a stream where it is ponded by a dam, or if there are ponds on the stream below the point of discharge, the solid particles of the sewage may accumulate and decompose, giving off offensive gases."

In the report of the Joint Board, in 1894, the ordinary summer flow of the Charles at the Watertown dam was placed at 62 cubic feet per second, and the minimum at not more than half that. Let the values at

* Report, State Board of Health, 1890, "Water Supply and Sewerage," page 791.

Craigie bridge be taken, respectively, at 35 cubic feet per second, minimum; 75 for ordinary summer flow, and 175 for the maximum in the driest five months; then, if the water were pure, and the mixture of sewage with it were uniform, and the mixture were carried off at once by a current, the sewage of from 4,000 to 5,000, from 9,000 to 10,000, and 20,000 or more persons, respectively, would perhaps be adequately diluted to prevent offence to smell. The conditions mentioned would not, however, prevail in a fresh-water basin.

The summer temperature of the water in the proposed basin would be materially higher than in the present one, — a condition favoring still farther the putrefaction of impurities in the water, and unfavorable to the cooling of the air. For much of the warmer season the difference of water temperature under the two conditions is likely, I believe, to amount to 8 or 10 degrees for the basin proper. The temperature of the sea water at Charlestown Navy Yard was taken daily throughout the year 1863 for the U. S. Coast Survey,* and the averages of the observations by months are plotted on diagram M. It will be noticed that there was no month in which the water at the Navy Yard averaged higher than 65°.

Comparison of Temperatures of Sea Water and that of Fresh Water Reservoirs.

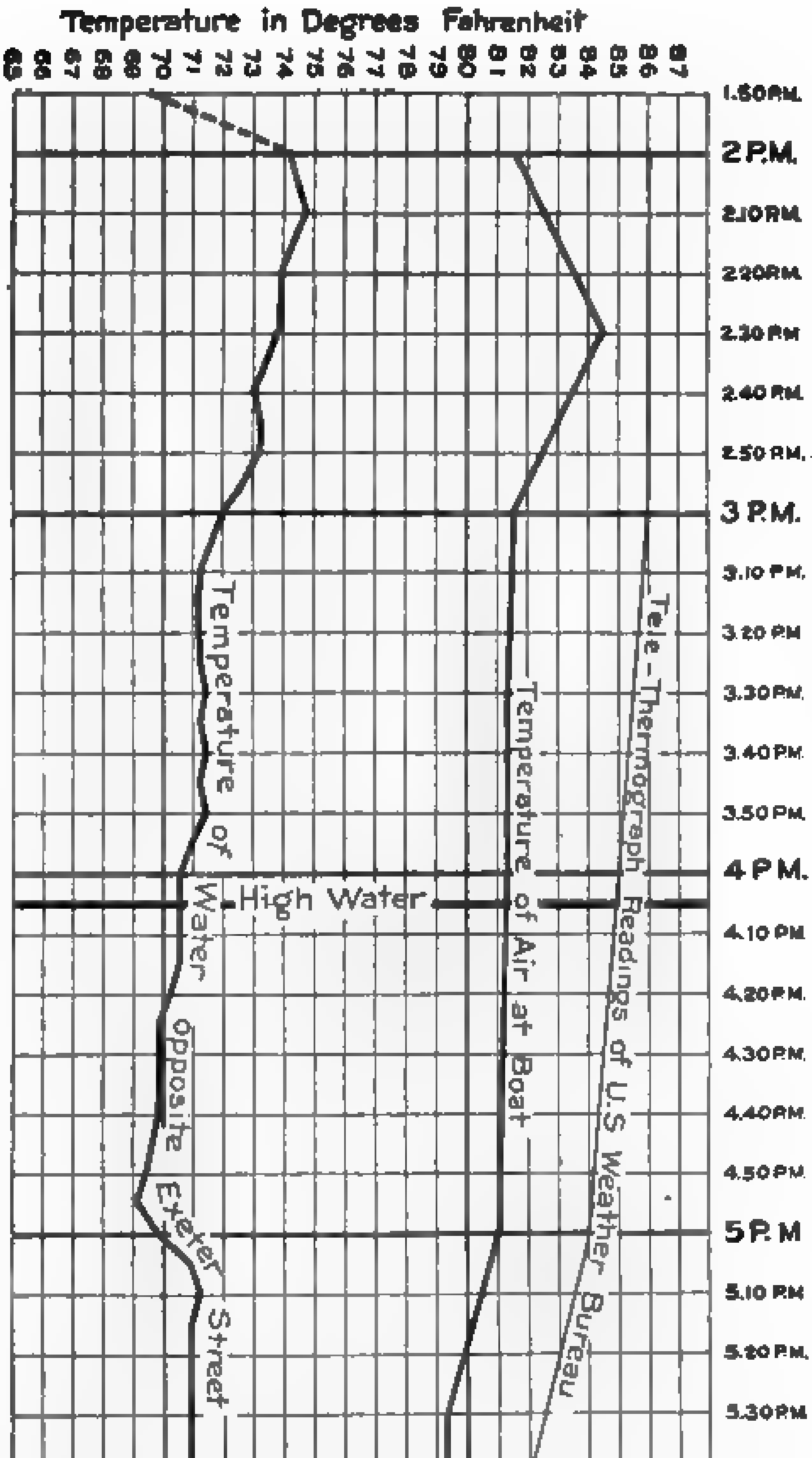
MONTHS.	Mean of Three Massachusetts Reservoirs for Ten Years (Degrees F.)†.	Sea Water at Charlestown Dry Dock, 1863 (Degrees F.).	Excess of Reservoir above Sea Water (Degrees F.).
January, ...	35.3	33.1	2.2
February, ...	35.3	32.2	3.1
March, ...	36.7	33.1	3.6
April, ...	44.3	42.9	1.4
May, ...	57.7	52.9	4.8
June, ...	67.9	58.2	9.7
July, ...	73.7	64.9	8.8
August, ...	72.9	64.9	8.0
September, ...	66.9	61.5	5.4
October, ...	55.2	54.8	.4
November, ...	44.1	45.9	—1.8
December, ...	36.1	34.7	1.4

The breezes blowing from the proposed basin would, in my judgment, be somewhat warmer than under the same circumstances from the present one, and, on account of the odors likely to develop in the stagnant fresh water, less wholesome. Observations as to the air temperature over the present basin were made under my direction on five days scattered through August, 1894. They were made in a boat anchored half way across the basin opposite Exeter Street, and were conducted for periods of from three to six hours on each day. Comparison with the continuous thermograph readings at the Signal Service station showed the air temperature at the boat to be uniformly lower than at the Signal Service station, by amounts ranging all the way downward from about 8° F. (see diagrams N–Q).

12. I believe that to raise the average level of the river surface, as would be done by the proposed dam, would raise materially the level

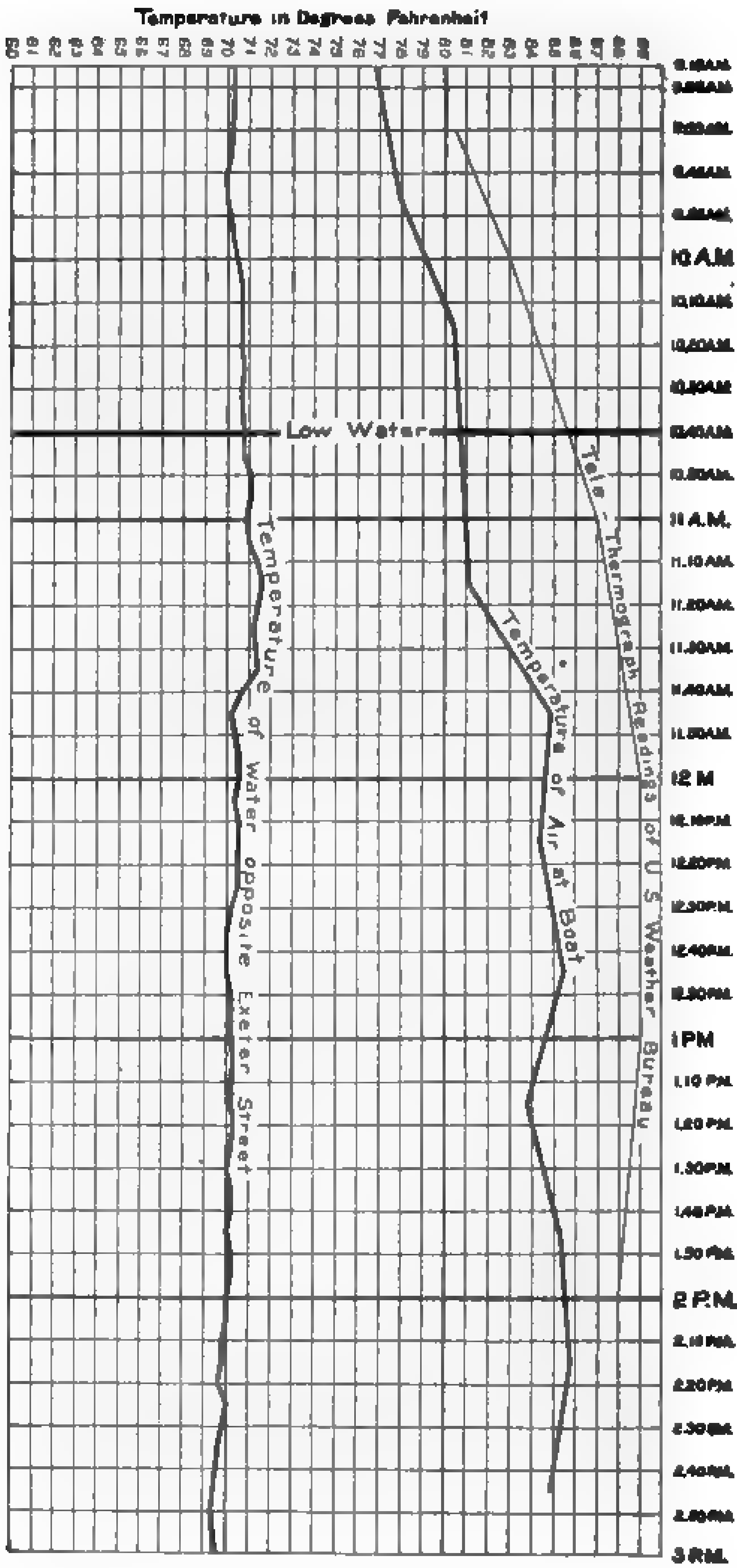
* As it seems possible that no other similar observations have been taken in this vicinity, the original letter from the Coast Survey office, with the observed temperatures in detail, are appended to this paper.

† Report, State Board of Health, 1890, "Examination of Water Supplies," page 663.



Temperatures in Charles River Basin, August 7, 1894.

Diagram N. Dwight Porter on Charles River Dam.

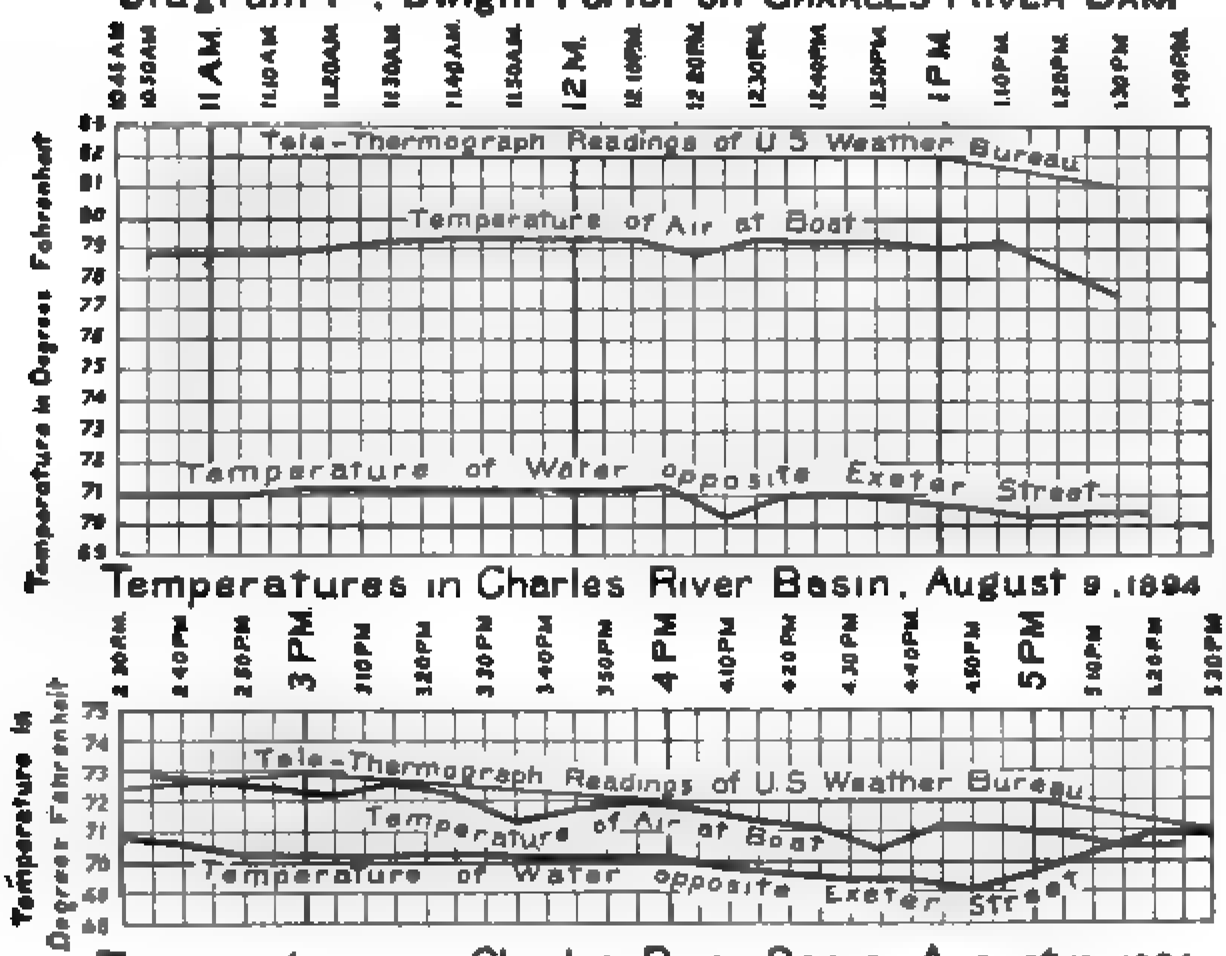


Temperatures in Charles River Basin, August 6, 1894.

Diagram O, Dwight Porter on Charles River Dam.

of ground water in adjacent lands, thereby interfering with their natural drainage, making more costly their artificial drainage, and leading to unsanitary results in that the development would be favored of all diseases promoted by wet soil, such as malaria and consumption. Twenty-five years ago the commission, consisting of E. S. Chesbrough, Moses Lane and Dr. Charles F. Folsom, which devised the Boston main drainage system, declared that the ground water in the Back Bay proper was "too near the surface,"* and its level appears not to have lowered since. The ground water is, of course, composed of rain which has percolated down from the surface. In the case in question it is not merely rain which has fallen on the land under discussion adjacent to the lower Charles, but that which has fallen on the uplands, even for miles inland, and is slowly but steadily flowing

Diagram P, Dwight Porter on Charles River Dam



Temperatures in Charles River Basin, August 9, 1894

Temperatures in Charles River Basin, August 10, 1894.

underground toward the coast. The surface of this sheet is not level, but follows in a modified way the topography of the surface of the ground, having, however, a general slope towards tide water. Its surface slope and therefore its height at any particular point are dependent in part, as in the case of any flowing water, upon the height of the body of water into which it discharges; and if that height be raised, the height of the ground water will tend to be raised. Without a dam, the average level in the Charles River basin is about grade 5.4, referred to Boston base. With the dam as proposed, it would be raised to grade 8 or 8.6.

It is sometimes said, however, that the sewers completely control the level of ground water in the sewered districts, and that, consequently,

* "The Sewerage of Boston," City Document No. 8, page 14.

the average height of the water in the river is immaterial. I do not doubt that the sewers exert an important influence, and that locally they often control the ground-water level, but I do not think that they are in general the determining force. Two cases, to be cited, throw some light upon the question.

In studies made by the Massachusetts Drainage Commission in 1886, marsh land lying in Saugus was examined, with a view to its possible use for sewage disposal, and is thus described on page 143 of the commission's report: "It is the tract of meadow land lying to the westward of the Lynn turnpike in Saugus and Revere, in the vicinity of Pines River. The total area of this tract is more than 1,000 acres. Its surface is very flat, averaging about 1 foot above ordinary high-tide level, or about 11 feet above low tide, the higher land being principally in Saugus. Some 25 borings made, and more than 100 holes dug with the spade during the past year, over a portion of this tract including about 500 acres, show that the soil consists of moderately coarse sand, sometimes reaching the surface and sometimes overlaid by a layer of peat from a few inches to 3 feet in thickness. Ground water ordinarily stands about 4 feet below the surface, and can be lowered by drainage."

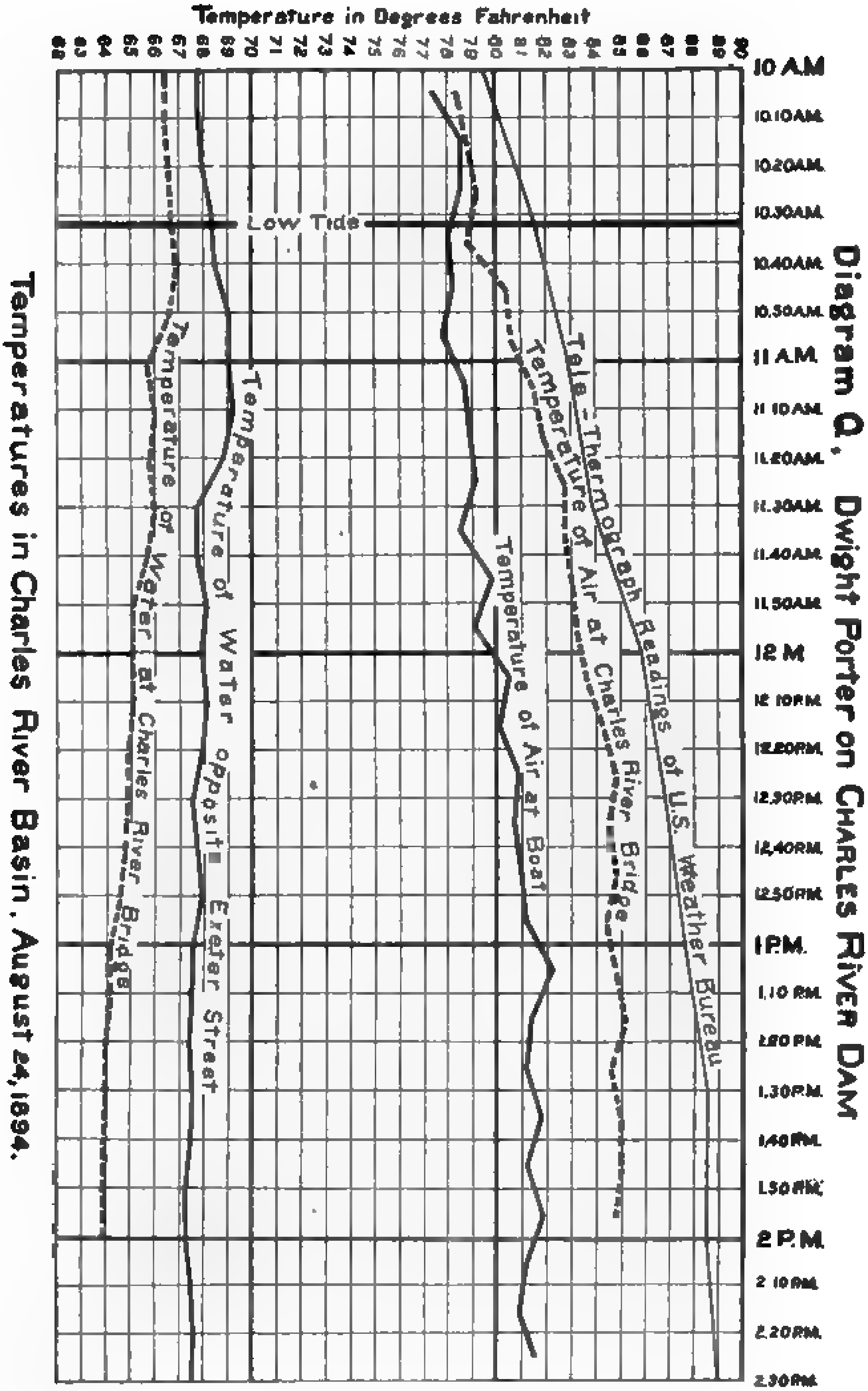
The height here found for the ground water, in a tract absolutely devoid of sewers, was not greatly different from that existing in the Back Bay district, — if anything, somewhat lower.

Again, when the main drainage system was built, some twenty years ago, there was some fear that the life of piles supporting adjacent buildings might be somewhat lessened through a possible lowering of the ground-water level by the proposed intercepting sewers, and the question was studied, as follows: * —

"To see if such danger was to be apprehended, it was decided to produce in one of the Back Bay sewers the precise condition which would exist if the new system was constructed, and to notice the effect upon the soil water. To this end, a steam pump was put into the Berkeley Street sewer near the outlet, and by continual pumping (except at low tide) the sewage was kept but a few inches deep, as it would be if discharging into an intercepting sewer. Previously, 20 pipes had been driven below the surface of the soil water, — some within a few feet of the sewers, others a few hundred feet away, and still others several blocks distant. The height of the soil water standing in each pipe was measured twice each day during the continuance of the pumping. It was found that the surface of the soil water was nearly level over the whole Back Bay district, averaging 7.7 feet above mean low water, and its height, while slightly affected by local contours of the surface, was independent of the sewers in its vicinity. For instance, the water in the vicinity of the Dartmouth Street sewer was at the same level as that near the Berkeley Street sewer, although the latter sewer is two feet lower than the former. Also, it was found that the soil water rose and fell, responding quickly to any rain or melting of snow (the extreme rise due to 4 inches of surface water being 1 foot), and that the variation was nearly uniform over the entire district.

"Finally, it appeared that the pumping, which continued fifty-three days, affected but slightly, and that only within 100 feet of the sewer, the soil water in the vicinity of Berkeley Street. At the close of the experiment, the sewer resuming its former conditions, the soil water in

* "Boston Main Drainage," page 26.


Temperature in Degrees Fahrenheit
62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90
10 AM
10.10 AM.
10.20 AM.
10.30 AM.
10.40 AM.
10.50 AM.
11 A.M.
11.10 AM.
11.20 AM.
11.30 AM.
11.40 AM.
11.50 AM.
12 M.
12.10 P.M.
12.20 P.M.
12.30 P.M.
12.40 P.M.
12.50 P.M.
1 P.M.
1.10 P.M.
1.20 P.M.
1.30 P.M.
1.40 P.M.
1.50 P.M.
2 P.M.
2.10 P.M.
2.20 P.M.
2.30 P.M.
Low Tide
Temperature of Water at Charles River Bridge
Temperature of Water opposite Exeter Street
Temperature of Air at Boat
Temperature of Air at Charles River Bridge
Tele-Thermograph Readings of U.S. Weather Bureau
Diagram Q, Dwight Porter on Charles River Dam
Temperatures in Charles River Basin, August 24, 1894.

its immediate vicinity rose from an inch to an inch and one-half, and thereafter fluctuated in unison with the water in other localities.

"The experiment was thought to show that no dangerous lowering of the ground water need be apprehended in consequence of the adoption of an intercepting system."

The observations which have been cited seem to indicate that the influence of the sewers upon the general level of the ground water is very limited. In so far as it is exerted at all by them, it is determined by the height of the water level within them; and that height must tend on the whole to rise with time, as the section contributing sewage to the existing sewers becomes more densely populated. The tendency of maintaining the Charles at grade 8 would also be, on the whole, toward a somewhat higher average level within the sewers, since they could then never discharge into the river without first rising above grade 8. Further, the sewers constructed in late years have been made much more nearly impervious to leakage than the older ones, and have correspondingly less influence upon the ground water.

The limit of depth for house cellars in Boston is grade 12, or perhaps somewhat more than 4 feet above ground water, while the natural marsh level is between grades 10 and 11 Bordering the Charles are extensive areas, now or formerly marsh land, or even at one time entirely overflowed, in which the height of the ground water is of especial consequence in its bearing upon the health of those living upon or adjacent to such areas. The minimum depth at which it should be considered safe to have permanent ground water below the surface of inhabited land, or below cellars, cannot be very definitely stated. The principle applying is that ground water is carried upward by capillary action, and so makes the soil above it wet. The vertical distance through which this action takes place varies with the character of the soil; and the rate at which the water is lifted diminishes rapidly with the height, but is known from experiment to be large through a height of as much as 4 feet of fine sand or medium clay loam,* so that, in fine material, even a higher clearance than 4 feet would seem necessary. If water is carried freely upward, the surface soil is made wet and therefore also cold, and conditions are established favorable to the development of catarrh, consumption, malaria and perhaps other diseases. It is well known that more than thirty years ago Dr. Bowditch, of this city, clearly showed a close relation to exist between soil moisture and consumption, which was independently confirmed by inquiries in England. Prominence was given to the matter in the very first report issued by the State Board of Health.

In the third annual report of the Board, the secretary, Dr. Derby, presented a paper entitled "Mill-dams and Other Water Obstructions," giving numerous illustrations of the unsanitary results produced in this State by dams constructed across both fresh-water and tidal streams. In particular, with reference to ponds shut in from the sea for the use of tide mills, he cited a local example as follows (page 68): "A striking instance of this form of nuisance, and on an enormous scale, may be seen in the present condition of what was once the receiving basin of the Boston and Roxbury Mill-dam Corporation, now in process of filling for the streets and houses of the most fashionable part of Boston. This has become a 'dead sea' of uncleanness, by reason of the obstruction to the free wash of the tide which is offered by the 'cross dam.'

---

* "Principles and Conditions of the Movements of Ground Water," F. H. King, in Nineteenth Annual Report, U. S. G. S.

During the summer of 1871 a territory of about 70 acres was thus kept nearly filled with stagnant salt water, the daily ebb and flow being almost entirely prevented, for the sake of the power which was thus given to a grist mill. It has sometimes been said that this half-stagnant water was retained in the basin to prevent the emanations from the mud along its borders at low tide. The answer to such defence is seen by comparisons of the two basins from the cross dam. In one the tide ebbs and flows freely at all seasons, and there is no offensive odor, although the great Stony Brook sewer empties into it; in the other, the tide is obstructed, and the odor is vile, although it now receives no sewage from any city drain."

For many years the ravages of malaria in various parts of the world have led men to study extensively as to the cause and means of prevention of this very serious malady. The literature upon the subject was very freely drawn upon and presented in testimony before the Harbor and Land Commission in 1894, and need not be again presented here. There has been pretty general agreement that imperfectly drained land, wet land, and stagnant water, supply favorable conditions for the development of the disease; and, although very recent studies and experiments have seemed to demonstrate that a certain kind of mosquito is essential to its spread, a knowledge of the dependence of this mosquito upon stagnant water for depositing its eggs simply confirms the general theory, long entertained, as to the close relation of wet land to malaria. In so far as the proposed dam should raise the level of adjacent ground water, it would favor the formation and persistence of surface pools of water, in which the *Anopheles* is said to lay its eggs. Further, in the basin itself, along the shores, it seems to me that the conditions would be more favorable than now to the *Anopheles*, inasmuch as this insect appears not to breed in salt water;* inasmuch, also, as the temperature of the fresh water would for a much longer period be within the range of 64° to 77° F., in which the mosquito is said to thrive, † than is the present salt water; and because of the probable abundance in the fresh water of algæ, upon the spores of which the larvæ largely feed.

Malaria is not to be regarded by any one familiar with the facts as a merely imaginary evil in the case of the Charles, but as an actually present malady, of so serious a nature that every effort should be made to prevent its further spread. Its importance was recognized, and attention was plainly called to it, in the report of January, 1893, of the Metropolitan Park Commissioners. Under the heading, "The Menace of Malaria" (page 47), they said: "But, with all these sources of contamination eliminated, there yet remains one of the greatest menaces to public health, and that is the malarial troubles which have arisen in the valley of the river within the past decade. Malaria was previously unknown in this portion of New England, but the trouble has been gradually creeping this way from the westward and southward, until its germs now appear to be well established in various sections of the country around Boston, particularly in the valley of the Charles River, where it is recognized as one of the most serious of evils. It hardly need be said that too decisive and radical measures cannot be taken to remove this danger, which, if allowed to establish itself permanently, will prove a fearful detriment to the various cities and towns which it afflicts, the possible damage from which is beyond estimate."

Finally, it is perfectly obvious that the limiting depth of practical

* "Mosquitoes," L. O. Howard, page 209. † *Ibid.*, page 109.

drainage of marsh lands by the commonly practised gravity method alone, would be lessened by several feet if the dam were constructed. The sub-surface drains now discharging freely for one-half the time, all along opposite Soldier's Field and the Speedway, for example, would have their outlets always submerged under 2 or 3 feet of water.

13. A contributing force towards preserving a proper channel depth in the harbor would be destroyed. This matter is not, however, within the scope of what I have been asked to consider, and will not be enlarged upon.

In view of the facts which have here been set forth in detail, I am of the opinion that little advantage is offered by the building of a dam below the present Charles River basin, beyond that possibly due to the improved appearance of a higher water level; and there is even room for question as to whether the monotony of a constant high level is preferable to the variety accompanying the rise and fall of the tide, provided that in the latter case offensive flats are not laid bare. On the other hand, the unnecessary sacrifice that is proposed of the advantage lying with the regular ebb and flow in the river of a vast volume of sea water, the unsanitary conditions invited by the change, the uncertain elements involved, the unknown but evidently great outlays likely to ensue as a result of meddling with systems of drainage which have been adapted to existing conditions in the river, added to the expense of the undertaking itself, are sufficient reasons, in my judgment, why a fresh-water basin should not be established.

Respectfully yours,

DWIGHT PORTER.

MEMORANDUM OF DIAGRAMS AND OTHER PAPERS ACCOMPANYING THIS REPORT.

Letter of acting superintendent, U. S. Coast Survey, with table of observed temperatures of sea water at Charlestown dry dock for the year 1863.

Illustrations A and B, Cambridge shore, near Gerry's Landing, showing treatment applied to river bank under present conditions, from 1900 report of Cambridge Park Commissioners.

Diagram C, predicted high and low water, Navy Yard, 1901.

Diagram D, computed curve of variation of level in proposed basin, assuming freshet inflow of 7,000 cubic feet per second, coincident with tides such as those of Nov. 27 and Dec. 5, 1898.

Diagram E, predicted tide curves.

Diagram F, number of vessels passed through draw of West Boston bridge, December, 1897, to November, 1898.

Diagram G, hours during which Binney Street regulator was closed, December, 1898, to November, 1899.

Diagram H, rainy days, Boston, 1892–1901; Greenwich, Eng., 1847–57 and 1880–90.

Diagram I, capacity for sewage and storm water of Boston main drainage system after completion of high-level sewer.

Diagram J, capacity of high-level sewer for sewage and storm water.

Diagram K, daily pumpage record, Charlestown and Deer Island pumping stations, April, July, August, October, 1900.

Diagram L, hourly pumpage rates, Charlestown pumping station, July 16 to 22, 1900.

Diagram M, comparison of temperatures, sea water and reservoir water.

Diagram N, temperatures, Charles River basin, Aug. 7, 1894.
Diagram O, temperatures, Charles River basin, Aug. 8,1894.
Diagram P, temperatures, Charles River basin, Aug. 9, 10, 1894.
Diagram Q, temperatures, Charles River basin, Aug. 24, 1894.

UNITED STATES COAST AND GEODETIC SURVEY,
WASHINGTON, D. C., Aug. 17, 1894.

Prof. DWIGHT PORTER, *Massachusetts Institute Technology, Boston, Mass.*

SIR: — In response to your inquiry of the 13th inst., I enclose a table showing the temperature of the sea water at Charlestown dry dock, Boston harbor, Mass., during the year 1863. The time of observation was that of the first high or low water occurring after or a very little before noon. The observer failed to state his method of taking these observations, but, since they were made for the purpose of reducing specific gravity readings, it is quite likely that he followed our usual custom, which is to draw a bucket of sea water up to the wharf, insert thermometer and hydrometer, and after a few minutes record readings of both instruments.

Respectfully yours,
WM. H. PUGH, *Acting Superintendent.*

TEMPERATURE OF THE SEA WATER AT CHARLESTOWN DRY DOCK, BOSTON, MASS., 1863 (IN DEGREES).

DATE.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1, . . .	33	34	33	38	53	64	68	60	64	57	48	41
2, . . .	32	35	35	38	54	62	66	59	63	56	48	40
3, . . .	33	34	34	39	54	59	66	64	63	56	48	40
4, . . .	33	29	33	36	48	62	66	61	63	56	48	38
5, . . .	34	28	32	36	46	58	63	60	63	57	48	38
6, . . .	35	30	32	36	46	61	60	60	63	58	48	36
7, . . .	34	31	32	37	45	40	59	60	63	58	47	36
8, . . .	32	32	32	37	45	60	60	60	67	56	47	37
9, . . .	32	32	32	37	46	51	60	63	66	59	45	35
10, . . .	32	33	32	38	48	52	59	69	65	58	44	34
11, . . .	32	34	33	41	49	54	59	69	65	57	42	33
12, . . .	32	33	33	44		58	69	67	65	57	44	33
13, . . .	31	32	32	46	55	56	59	66	63	57	44	33
14, . . .	31	32	32	47	61	59	62	65	63	54	44	34
15, . . .	34	33	32	48	62	60	63	64	63	54	45	34
16, . . .	37	34	32	46	58	62	67	65	63	55	46	35
17, . . .	35	33	32	46	52	60	68	63	64	56	46	34
18, . . .	33	31	34	46	54	59	65	64	64	56	48	34
19, . . .	32	34	31	43	56	58	60	64	64	56	47	36
20, . . .	31	35	32	42	52	58	64	65	61	55	48	37
21, . . .	32	34	32	45	54	58	66	66	58	56	47	37
22, . . .	32	31	31	45	55	59	67	66	59	57	47	38
23, . . .	33	30	32	48	55	59	67	69	59	55	46	32
24, . . .	33	31	33	46	55	61	68	71	59	54	46	31
25, . . .	34	31	33	45	55	60	68	73	58	58	45	30
26, . . .	34	32	35	44	55	60	67	70	56	53	44	30
27, . . .	34	32	34	44	56	61	71	68	56	49	44	30
28, . . .	35	33	35	48	56	67	73	66	56	48	44	31
29, . . .	33	–	36	49	60	67	71	67	55	48	45	32
30, . . .	33	–	36	51	62	66	71	64	56	48	44	32
31, . . .	34	–	38		[illegible]	–	71	65	–	48	–	33
Averages,	33.1	32.2	33.1	42.9	52.9	58.2	64.9	64.9	61.6	54.8	45.9	34.7

REPORT OF RUDOLPH HERING.

JUNE 2, 1902.

Messrs. LEWIS S. DABNEY and others, *Boston, Mass.*

GENTLEMEN: — Complying with your instructions to examine into the proposition to build a dam across the Charles River in its tidal reach, and to report to you the probable effects of a basin, caused thereby, upon the healthfulness of the surrounding territory, and to state any other matters of import resulting therefrom which might affect your interest in the same, I visited the site of the proposed basin, between the Arsenal and the Navy Yard, although already familiar with much of the territory, also the Back Bay Fens, examined the plans concerning the basin and dam on file at the office of the commission, 18 Beacon Street, read over the various reports relating to the subject, including the record of the hearings of the previous commission of the year 1894 and also of the present commission, and now respectfully present the results of my inquiry, based upon this special examination and my experience in similar matters for many years.

Others, also engaged on this case, have made extensive surveys, compilations and analyses, which have been accessible to me. It was therefore unnecessary to repeat the same, and some of my conclusions have been based directly upon them.

It has been proposed to construct a dam across the river several hundred feet above Craigie bridge, or further up stream, and thus establish a basin of fresh water, or nearly so, to be kept at practically a constant elevation of 8 feet above Boston city datum, or about 2¼ feet below mean high tide. This basin is intended to form the chief feature of a "water park," to extend from Craigie bridge several miles up the river. The project was presented in its chief outlines in 1894 by a report of the Joint Board upon the improvement of the Charles River.

Opposition having arisen to the manner in which it was proposed to carry out the work, it is intended at this time to inquire thoroughly into the merits and demerits of the proposition.

In favor thereof, it is said that the creation of this basin would form the centre of a grand park system for the metropolis, with practically a constant water level extending from the proposed dam to Watertown, with pleasing shores, having grass and trees extending to the water's edge. It is said that such a development of the respective territory would be a great benefit to the large future population surrounding it, and that not only the general community but the private interests adjoining such a park would be greatly benefited.

In opposition, it is said that the abandonment of the tidal flow of salt water reaching far up the river would cause serious injury to the sanitary condition and comfort of the surrounding community; that the discharge of overflowing sewage into a practically stagnant pool would be a danger to health; that as a park it would not fulfil all the anticipations of the proposers; and that it would seriously injure the Boston harbor by its effect upon the depth of the channels.

As a result of my careful examination of the various facts and conditions in the premises, I am led to the conclusion that, unless other arrangements are added, not heretofore definitely expressed, the basin as proposed would unquestionably have disappointing results, and possibly be injurious to health and property, and certainly to comfort, defeating thereby in a large measure the objects so greatly desired.

Effects relating to Health and Comfort.

A. — Pollution of Basin.

The present condition of the Charles River below the Watertown dam is such that at times it is in a somewhat unsatisfactory condition. There are extensive areas of flats, foul looking and foul smelling when exposed at low tide, and therefore offensive under favorable winds, tides and temperatures.

The minor causes for this condition are reported to be the dumping into the river of refuse, street sweepings and horse dung, all of which can and should be readily prevented by police regulations.

The major causes are the overflow from the metropolitan sewers, the rain water washing the street surfaces and the harbor refuse drifting up stream with the flood tide and depositing on the flats during slack water.

Irrespective of the question of a dam, it would appear that the sewage and street wash should be kept out of this basin to a much greater extent than is now effected, sufficiently to obviate the extensive deposits of foul matter. The harbor refuse drifting up stream is probably not large in amount, and is also the least serious of the polluting matter; without a dam other than a boom stretched across the river, there appears no practicable way of preventing a deposit or stranding of at least some of this matter at the change of tides.

If a dam is built, the conditions are less simple. As the harbor refuse is prevented from drifting above the dam, this element enters no further into the question. The sewage and street wash, however, which enter the basin from the sewer overflows and street surfaces, form the other element of pollution, and a most careful consideration must be given to the effects thereof so far as they have a bearing upon the question before us. Mr. X. H. Goodnough, chief engineer of the State Board of Health, says of the sewers discharging into the Charles River that the "first overflow at the beginning of storms is very bad." Also Mr. Percy M. Blake grants that during the storms the overflowing sewage is "offensive," and speaks of the "filthiness of the liquid."

In this special case I hold that still another requirement is justified and necessary. A park such as is proposed is intended to be attractive to a high degree. Located in the midst of large population, it is rightly expected that it shall not contain any offensive features, nor even suggestions of them. Sewage odors and foul matter stranded along the shores should have no existence where health and recreation are sought, and amidst surroundings which have been conceived and executed under the guidance of high art.

Under the existing conditions, I firmly believe that when the growth of population using and contributing to this park will have reached its maximum, complete satisfaction cannot be obtained unless the sewage and foul surface waters from the city area have been practically excluded. It is my opinion, and it has been expressed before in a similar case, that where the question concerns a park, all sewage, and even the washings of frequented streets, which are often as foul as sewage, should be kept out of any water-course within the same, so far as this may be possible.

It has been stated that the foul water entering the proposed basin from the overflows of the sewers would not be objectionable. This statement is made on the strength of an assumption that a river flow at the rate of 10 cubic feet per second per 1,000 persons sewering into the same has been known to so dilute the sewage that the water into which it had

been discharged did not become offensive. A dilution to this extent is recommended, although it is admitted by Mr. Blake that for the month of September the average dilution might only be 8.4 cubic feet per second per 1,000 persons, from which it must be inferred that on some days during the month it will be still less.

As applied to the present case, I must emphatically dissent from the opinion that such a pollution would be inoffensive. The assumption is based upon empirical data which have been collected for a number of years. The observations of streams, as to their polluted condition, indicated that there was a fair relation between the quantity of their flow and the number of persons whose sewage entered them. There is a variety of conditions as to streams as well as to sewage, but roughly it is assumed that the average sewage of 1,000 persons will not be offensive in a running stream if it is diluted by a flow of from 3 to 10 cubic feet per second, depending on the specific conditions. This formula,* however, does not apply to the present case, for the following reasons: —

It was deduced from cases where the sewage and the water of the stream had become thoroughly mingled after flowing some distance in a fair current. It applies to pools formed by a dam only after such a mixture had been effected. It presupposes also that a deposit of the heavier matter had taken place, leaving the water to hold only the dissolved and fine suspended sewage matter. The data from which it was deduced all refer to fresh-water dilution. In brackish water, to obtain the same results, the dilution would have to be greater.

In our present case these conditions do not exist. We have a basin of practically quiet water, with very slight velocities during the late summer flow (see Table I.). Not only the velocity of the water decreases, but the thread of the current will vary at times with the winds; generally it will be near deepest water. The winds may also tend to hold the sewage near the shore outfalls. The shore velocities are practically nil, and will readily allow whatever matter enters at the shore, and is heavier than water, to deposit near the same. It is not thought necessary here to give evidence of the relation of the velocity of a current to its suspending power. The liquid sewage, and whatever matter may still be held in suspension, moves very slowly in a basin of from several hundred to 2,000 feet in width. How can there be, under this condition, a thorough mingling of the sewage with the water of the entire cross-section of the river? The overflowing sewage, as a matter of fact, would drift a long distance with a very slight dispersion before it is lost to sight.

A deposit would unquestionably accumulate along the shore, and, even if it does not become offensive, it might at least suggest the accumulation of sewage by the appearance of the water and a slight musty odor at certain times. The overflow pipes could be extended some distance from the shore. Yet visitors to the park will not be only at the shores of the basin, as boating and bathing will form some of the attractions of the park. While a pollution, such as an overflow would create, might be less objectionable in the open water than at the shore, it is unquestionable that during the long summer droughts, when thunderstorms throw into the basin quite a lot of foul matter, it would sufficiently pollute some portions of it so as to make boating less attractive.

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* (1) "Notes on Pollution of Streams," by Rudolph Hering. Transactions, American Public Health Association, Vol. XIII, 1887. (2) "Pollution of Streams," by F. P. Stearns. Special report of Massachusetts State Board of Health, 1890, Part I., p. 785. (3) "Dilution Process of Sewage Disposal," by Rudolph Hering. Engineering Magazine, Vol. 15, 1898.

Neither the sewage deposits near the shores nor the drifting sewage in the stream are, in my opinion, conditions to be permitted in a park of a great city.

It is well to consider at this point the nature of the overflowing sewage in times of rain. Let us suppose an overflow to take place with rain water reaching the sewer at the rate of just over one-quarter inch in twenty-four hours, which roughly equals the maximum flow of sewage in the interceptors. The increased amount of water entering the sewers increases the velocity of flow, and matter which has been deposited or is attached to the perimeter is torn away by the quicker current and carried along in suspension. It is therefore quite common to find at the beginning of a rain that the water flowing in a sewer when it is about to overflow into a river is more foul, and carries more matter in suspension, than when flowing in the sewer at ordinary times. It is quite erroneous to speak of the overflowing sewage as being "at all times highly diluted by rain water." It is never so until after the rain has continued long enough to have thoroughly flushed and cleansed the sewer, and when the rain water receives only the freshly contributed sewage. There are many storms in the year which are too short in duration to admit of this thorough cleansing. As summer showers are the most intense, as a rule, overflows are then also greatest at such times when the park is most used. The amount of solid deposit from each overflow may be but a few cubic yards per annum, yet a continual decomposition is going on, which by its effects increases the already unpleasant features.

The theoretical computations of the amount of filth escaping from overflows may be far from giving true results regarding the expected quality of the water, for such calculations are generally based on averages. I cannot agree to such a method of computation in this case. It is not a question of averages in the case of a park, but of the worst conditions, — worst not only as to character and quantity of escaping sewage, but also as to time of year, when streams are lowest, in hot, dry weather, and when parks are most frequented, most necessary and most useful. While overflows into a river where a temporary pollution is of no moment are quite proper, they are out of place in a river when it forms an important feature of a great park, and particularly where the velocity of its summer water, when sudden thunder showers are apt to belch out a specially large amount of sewage, is insignificant.

It has been said that foul stagnation does not occur in a sheet of water if it contains a sufficient quantity of dissolved oxygen, and if it is large enough to be frequently agitated by the winds. This is true. Yet it is also true that, because the river flows for many miles through improved territory, the amount of this oxygen will be relatively small in hot weather when the water reaches the proposed park. To maintain it in a satisfactory condition, it is, therefore, especially important to restrict the inflow of all matter which in decomposing will consume the remaining oxygen, and by forming nitrates facilitate the growth of aquatic plants of low order, which develop in greater numbers in fresh than in salt water.

It has further been said that the creation of a fresh-water basin will increase the purity of the impounded water. This, however, can follow only if no organic matter is allowed to enter it to settle at the bottom, or remain suspended or dissolved, seizing upon the available oxygen.

It is stated by Mr. William M. Brown, engineer of the metropolitan sewerage works, from observations at the Cambridge regulators, that, by assuming averages, about 7 per cent. of all the sewage of the

year passes out into the Charles River through the overflows. From what was said above it is possible that more than 7 per cent. of all the filth actually reaches it. Should this proportion be discharged into a quiet pool, in the season when a park is most frequented, the results would not be wholly acceptable to the public.

A word should be added concerning the air pollution which arises from escaping gases and bursting bubbles on the surface of the water, also from the winds carrying with them the odorous gases and bacterial masses from among shore deposits.

How much of an odor would be thus produced under the proposed conditions it is difficult to say. We know that very small amounts of putrescent matter may, under favorable conditions of warmth, moisture and air movement, give unpleasant, stale and annoying odors. We also know that there is a growing tendency in our cities, as well as homes, to demand everywhere as good air as possible. Every industrial work that is apt to produce unpleasant odors is now relegated to a distant point. In the best residential districts we find objections to the faintest odor suggesting a disagreeable origin. This tendency is increasing, and it seems to me that it is but a reasonable demand in our cities that particularly in their parks not a suspicion of offence should be tolerated.

The tidal flow would produce greater velocities and quicker dispersion than would obtain in a fresh-water pool, particularly if all the overflow pipes are carried out into the stream.

The conclusions here stated, concerning the effects in the proposed basin, hold good even after the high-level interceptor will have been finished and to some extent has relieved the present conditions. It is only a question of time when the increase of population and of sewage will have again caused effects similar to those now observed, unless a more radical change is effected.

It is not to be inferred that the sewage pollution of the basin by overflows is necessarily dangerous to health. The connection between such pollution and any specific disease would be difficult to establish. It is rather a question of comfort, of pleasure and recreation for the visitors to a park, and for the inhabitants of the near buildings.

It is a question also of financial value of such comfort, which naturally must be determined by the community which pays for it. Generally it can be said that the value of pure air in large cities and of parks for recreation is constantly increasing, and larger expenses for such purposes are more willingly incurred to-day than were thought necessary some years ago.

Expenditures for parks are considered under three aspects: health, comfort and luxury. There is no difficulty in obtaining funds in a wealthy city for any purpose that is clearly conducive to health. It is less easy to obtain them where devoted merely to comfort, and funds for works of luxury are forthcoming only where there is a surplus of wealth and a desire of the community to have them.

It is my belief that in the present case we should insist on a sufficient expenditure at least to cover the requirements both of health and comfort. If it is desired to expend funds in addition also for the luxury of having a beautiful water park, with a basin full of practically pure water, then I maintain, from what has been said, that a sufficient sum of money should be devoted to the exclusion of all sewage and foul water from the basin.

As to the advantages of salt water over fresh in relation to the question before us, it must be said that salt water appears to us the more pleasant and invigorating.

Frost attacks fresh water quicker than salt, and a quiet body of water quicker than one that is flowing rapidly. We must, therefore, expect the proposed basin to freeze over more readily than the present tidal basin. While this has an advantage for the park if the ice becomes thick enough, there is a disadvantage for navigation in the winter which may be correspondingly injured, and the value of the injury should be given consideration. Below the dam the velocity of the river would become less and the freezing greater, damaging the shipping facilities in proportion.

Another difference in the effects between fresh and salt water is the relative behavior of sewage in the same. In salt water sewage is decomposed less quickly than in fresh water, and therefore accumulates more rapidly. There is a greater tendency in salt water to precipitate suspended matter, and during slack water cause foul deposits on the beds.

The salt water changing with the tide twice a day will necessarily have a lower temperature than the quiescent fresh water held back in the basin during hot and dry weather for many weeks. Others have taken some observations to determine this difference. While the difference in the temperatures of the air of the adjoining park would not be as great as the difference in the temperatures of the two waters, yet as regards temperature the present condition of flow without a dam certainly has some advantage.

As regards bathing in salt water, the weight of opinion is in favor of its superiority over fresh-water bathing.

The effects upon animal and vegetable life of converting a body of water once largely salt into a fresh-water lake present another serious question. Although there is organic life which for a while can live in both waters, a permanent change causes their destruction and decay, with results possibly as objectionable as sewage pollution. Whether this decay would cause specific diseases is, I believe, doubtful. It is certain, however, that it would cause some unpleasant odors and consequent discomfort until a complete decomposition had taken place, and for this reason is objectionable in a park.

Although from its greater specific gravity such sea water would tend to remain near the bottom and destroy whatever fresh-water fauna and flora may have developed during the preceding seasons, it is at least questionable whether the roots of trees and shrubs planted near the shores would not also be injured by spasmodic salt percolation.

At present low tide uncovers a large area of flats; these flats are unsightly, and emit an odor due to putrefying matter. The exclusion of all sewage from the basin would wholly remove this source of odors, but the unsightly appearance of the mud deposits would remain. It would therefore be desirable, as the basin is part of a park, to dredge the river bed to such a depth that at extreme low tides water would still cover the bed of the entire basin.

It has been stated that the walls required around the basin, if the tide ebbs and flows, would be unsightly, due to the slimy and discolored bands that may exist between high and low water marks. It would not be necessary to have such walls around the entire basin, and where they exist it would not be impracticable to give them an annual cleaning, and thus to a great extent prevent the objectionable appearance. Along most of the basin it is possible and less expensive to maintain sloping shores instead of the expensive walls. These can be carefully graded, as done on Captain's Island, and, when sewage is strictly excluded, present an unobjectionable appearance at low tide.

In summing up the effects to be expected from a pollution of the basin,

it is my opinion, for the reasons set forth, that the arrangements as proposed would bring disappointing results when the project is viewed in the light of a water park. The amount of sewage which is to be allowed to enter the basin at its shores is too great to be evenly dispersed throughout the basin by the slight summer flow of the river. Most of the solid sewage will remain suspended or deposited near the shores, and create conditions unworthy of a park.

The exclusion of salt water from the present river by building a dam is a distinct disadvantage, both in allowing an increased temperature to prevail in the hot and dry months, and in the loss of salt-air breezes and salt-water bathing. The loss of these advantages must be offset by greater advantages to be secured through the proposed non-tidal park basin, if the latter is not to be inferior in merit.

There should be a much more complete interception of sewage and street water than that proposed. It is necessary to make a far more detailed investigation than was required for the present purpose, to state just how much more of the foul water should be intercepted, and to give details of arrangements and of cost.

It will suffice to say that, instead of intercepting one-fourth inch of rainfall per twenty-four hours, my present knowledge of the case indicates that if not all storm water, an amount of at least one-eighth inch per hour, perhaps double this amount, should be excluded, leaving but few occasions for any overflow to take place during a year. The one-fourth inch per twenty-four hours basis was borrowed from English conditions, where rainfalls are less intense than here. In our country we need a larger interception for ordinary purposes, and a still larger one if the overflow enters a park lake. The exact amount, in my opinion at least twelve times greater, is a matter of further examination and also of judgment in the light of available funds.

The interception should be accomplished by two new sewers built for this purpose, one on each side of the river. They should begin at least as far up as the upper limits of Cambridge and Brighton, and discharge below the proposed dam, at a distance to prevent trouble by the oscillating tide water.

It is clear that the intercepted storm water would require pumping, so as to be discharged below the dam perhaps at high tide. This might be most expeditiously accomplished at the dam, where attendance is required for operating its locks in any event, by low-lift centrifugal pumps, operated by electric power, such as are now being installed for lifting the much greater quantity of storm water at New Orleans.

Mr. Hastings has found it desirable to make a study of intercepting all the storm water from the Cambridge side of the river, and of discharging it below the dam by a large special sewer, for the purpose of keeping both the sewage out of the pool and the storm water at a lower level than is now possible when a storm occurs during high tide.

Mr. William M. Brown has given a similar opinion, and suggests that the first wash from the streets during storms be collected by intercepting sewers and discharged below the dam. Mr. Stearns and Mr. Goodnough have both stated that no sewage at all should be discharged into the basin, if it could be prevented. As hereafter mentioned in more detail, the treatment of the Alster basin in Hamburg has been based upon this view.

An interception of at least one-eighth inch per hour of the first wash from storms is practicable on both sides of the river. On the Boston side such an intercepting sewer should take also the ordinary flow of Muddy River and Stony Brook, unless the condition of their water can be very materially improved over what it is now.

In these large water-sheds a separate system would have a marked advantage for the present case. The storm drains could discharge the "first wash" into special sewers at frequent intervals, so as to get the foul surface water removed as effectually as possible to below the dam. Automatic regulators could stop the entrance of water from the drains after a given rate of discharge, and the later wash, which is fairly clean, could continue to the river. There would then be three points of disposal: the sewage would go to the lower harbor; the first street wash, up to at least one-eighth inch per hour, would go to the river below the dam; and the later wash during heavy rains into the pool above the dam.

There appears to be a possibility from the map of discharging the first street wash from the Muddy River and Stony Brook valleys into the South Bay at a less distance than into Charles River below the proposed dam. Whether the cost, including pumping, would be found less, I am not now able to say.

Whatever may be the expense of keeping the above-estimated amount of sewage and street wash out of the Charles River park above the dam, it appears to me that the wisdom of incurring such an expense should be determined by the financial value which the city places upon the increased comfort and luxury secured by a large water basin with perfectly clean shore bottom, and filled with water practically as pure as that found in the river above its present tidal estuary. If such value is deemed less than the expense of a much more thorough sewage interception than now in contemplation, the proposed dam should, in my opinion, not be built.

B. — Transmission of Disease.

When the Charles River dam case was heard in 1894, much was said concerning malaria or ague. It was held that damming the river would be productive of this disease. The late Col. George E. Waring stated that the entire sanitary question connected with the present proposition was embodied in the question of malaria; nothing else in the way of health disturbance was to be feared, and malaria had no relation to the sewage pollution through overflows, but was directly related to the moist lands bordering the river. At that time it was believed: —

1. That malaria had its origin in very damp earth.
2. That the drainage of swamps, marshes and any of moist land, in other words, the keeping of a constant low-water level had a beneficial effect.
3. That belts of trees and large sheets of water act as a defence against malaria.
4. That dampness, changes from dry to wet and high temperatures, were all favorable to malaria.

There has been much progress made in the discovery of the cause and transmission of malaria since the above conclusions were formulated. To say now that "the changing of Charles River from a salt-water to a fresh-water system will very greatly aggravate all malarial conditions" (Colonel Waring) has no longer such unqualified meaning.

Mosquitoes of the genus of *Anopheles* are to-day known to be carriers of the protozoa of malaria, which have their home in wet earth and vegetation, and which infest also our blood corpuscles, thereby producing this dreaded disease. They are being found all over the world. They breed and are most numerous in moist land, wet ditches, puddles and ponds with slowly flowing water.

John B. Smith, Sc.D., State entomologist of New Jersey, says: "*Anopheles* breeds in salt water as well as in fresh or brackish water. *Culex sollicitans* breeds in salt water only, and it may be more salt than the sea itself. Tide-water streams with clear banks offer no chance for mosquito larvæ of any kind. Fresh water at a constant level with sloping banks would favor *Anopheles* if any vegetation were allowed. If banks were kept clean and the water stocked with proper fish, there would be little or no danger. Brackish water is worse than either salt or fresh."

Culex is the most abundant species. It is not yet charged with being a carrier of the malarial protozoa. It breeds in brackish water, and even in water that was found to be fully 25 per cent. more salty than ordinary sea water. Some percentage of salt seems to be absolutely necessary for the development of the larvæ. In no case did Dr. Smith find them in fresh water, where the adults occurred in enormous quantities. The measures to exterminate the larvæ, Dr. Smith states, are ditching for the free entrance of tide water, and introducing certain small species of fish and other animals that feed on the mosquito larvæ.

Next in abundance is the species *Culex pungens*, which has also not yet been connected with malaria. It breeds in almost all sorts of places, provided there is water which is not salty, — in cess-pools, cisterns, reservoirs, sewage and even manure pits. The larvæ have been found also in neglected buckets and tin cans.

Dr. L. O. Howard, entomologist of the United States Department of Agriculture, says: "A large pool of water, fresh or brackish, will not breed mosquitoes except around its margins, where grass grows, or where the surface is otherwise not disturbed. Where the wind ripples the surface, mosquito larvæ are not found; where fish have easy access to them, they are seldom found." "Where a fresh water pond is maintained at practically a constant level, and no swamps are permitted to exist in the neighborhood, and where the margins of the pond are kept sharp and clean, and where lily pads and other vegetation is not permitted, the *Anopheles* mosquito will not find a favorable haunt."

The possibility is not yet excluded of there being another intermediate host than the *Anopheles*, but the evidence is satisfactory that malaria can be reduced, if not extinguished, by removing the conditions favorable to the propagation of these mosquitoes.

Says the Medical News (Vol. 79, No. 26, Dec. 28, 1901): "In a summer's observations in New Hampshire and Maine by E. O. Jordan (Trans. Chicago Pathological Society, No. 11, 1901), *Anopheles* larvæ were never found in large numbers except in unshaded waters and in meadows bordering small streams. Malaria has never been known to originate in these regions. The filter-basin waters, however, which intercept the ground water on its way to the rivers, and which supply many New England towns, are rich in nitrates and algæ, and are especially favorable to the development of *Anopheles*. Accumulations of surface water do not furnish proper pabulum for this malaria-breeder; but the organism finds abundant food at the bases of water-sheds, where the ground water comes into contact with light and air. Malaria, therefore, prevails along river bottoms and sea-coasts."

Professor Jordan also says that *Anopheles* will breed in salt water. "A high summer temperature would of course be favorable to multiplication of *Anopheles* by allowing a larger number of broods to come to maturity in the course of a single season. The growth of grass and weeds close to the shore and in sheltered bays will render possible the development of mosquitoes along the margin of quite large ponds."

Says Dr. Alfred G. Mayer, entomologist of the Brooklyn Institute of

Arts and Sciences: "A dam which would cause the salt or brackish water to be changed into fresh water would probably cause a decrease in the actual number of mosquitoes, for *Culex sollicitans*, our commonest mosquito, breeds only in salt water. The *Anopheles*, however, might be increased; and, as human malaria is transmitted by *Anopheles*, the region might become malarial, despite the decrease in the actual number of mosquitoes."

Concerning the malarial germ or parasite, it should be said that it inhabits, besides animals, also plants, and it is probable that the latter abode is the more general one, and from which the *Anopheles* receives it. Little, however, appears to be known on this branch of the subject. In the absence of positive information it, therefore, seems proper that we should at least assume that the protozoon lives on the sap of certain plants, growing under conditions favorable also to the growth of mosquitoes, from which these extract it in the search of food and incidentally transmit it to us.

We are therefore brought to a much more satisfactory position than was possible in 1894, when the project of the Charles River dam was first examined. We can now intelligently provide conditions which are unfavorable for the development of *Anopheles* larvæ, whether the case be a tidal stream or a fresh-water basin created by a dam.

The conditions unfavorable to the spread of malaria may now be stated as follows: —

1. Meadows, swamps and marshes should be thoroughly drained, so as to preserve in the ground as nearly as possible a constant water level, sufficiently far below the surface so as to prevent capillarity from keeping the surface continually very moist.

2. Grass, weeds and other vegetation should not be allowed to grow into the water, but the margins of the pond or basin, whether tidal or not, should be kept sharp and clean.

3. The water should contain proper fish and other animals that feed on mosquito larvæ, and if necessary and practicable it should be stocked therewith.

4. The growth of aquatic plants should be reduced as far as practicable by reducing the amount of nitrates in the water as much as possible, which is accomplished in a large measure by the exclusion of sewage matter and street wash, because the decomposition of organic matter produces nitrates.

From the evidence before us, there does not seem to be much positive information indicating a decided preference for either a salt or fresh water basin, so far as the propagation of malaria is concerned, although the preponderance of evidence slightly favors the former. The above preventative measures should be applied to both. Although the natural habitat of malarial protozoa is probably a fresh-water plant, we do not know whether or not such plants may grow also in brackish water. Of more importance is the carrier, *i.e.*, the *Anopheles* mosquito. It appears to breed alike in salt and fresh water, and, while containing the dreaded protozoa in its body, it is carried about by wind, on men and animals, in wagons, boats and trains, so that it has caused the disease at places distant from the stagnant pools from which it came.

C. — Drainage of Low Lands, Ground Water and Flooding.

Boston tides range about 10 feet. Low water, although its mean is grade 0.5, has reached grades 3, 4 and even 5 feet. High tides have gone above grade 15, while mean high tide is about 10.5. Mean tide level is about grade 5.4. The level of the marshes is from 10.5

to 12. The level of the ground water varies, but is about grade 8 along Beacon Street and higher in the undrained marshes.

Where sewers are built, unless they are made effectually water-tight, which is accomplished only when of great importance, they generally regulate and determine the ground-water level, and are sometimes built for that very purpose.

Another determining element is the character of the soil. If it is open sand or gravel, the slope of the ground water will rise gently from the nearest point of outflow at a rate of from say 5 to 15 feet per mile. If loam, or even clay, it will rise much more rapidly.

It is claimed that the establishment of a permanent level of the proposed basin at grade 8, with mean tide at 5.4, would not raise the ground water, but rather lower it in places. The reverse is also claimed.

When there is a fluctuating water level, as a tidal range of 10 feet, water will enter the ground on rising tide and run out on falling tide. When the soil is gravelly or very porous, the ground-water level will rapidly respond for several hundred feet, and beyond a certain point it will have a fixed level at slightly above mean tide and then gently rise toward higher ground.

If the soil is not so porous, and even mucky or loamy, it takes longer for the rising tide water to penetrate, and still longer for the water to drain out at low tide, because it is now held at a higher level by capillarity.

When the marshes are flooded at high tide the water enters the soil also from the top and is forced into it by its weight. When the tide recedes, the water that has penetrated the soil has a long and tedious journey to reach the river during low tide. Long before this happens, high tide has again appeared and a fresh flooding occurs. Therefore the average ground-water level on the marshes must be, and is, materially higher than mean tide level, which is grade 5.4. Witness the Saugus and other marshes.

If there is no tidal fluctuation, and the water level in the basin remains at grade 8, the ground-water level no longer fluctuates, but slowly adjusts itself to this constant level.

So far as the flooded tidal marshes are concerned, it seems to me, and agrees with other observations, that a fixed water level at grade 8, or 2½ feet below high-water level, would not raise the ground water, but rather lower it for some distance from the shore. It also appears clear that in the built-up sections, where sewers will be laid, if they are not laid already, the ground-water level will, or can, be controlled by the sewers. These will be closer to the cellars than the river, except, perhaps, should they run close to the shore.

I am not able to state, without tests, exactly how much the ground-water would be lowered by the proposed basin. I am satisfied, however, that a grade of the surface of the basin between 7 and 8 would lower the ground-water level on the marshes, and not raise it materially, if at all, on the higher territory bordering the basin, where it can be controlled by sewers.

The Back Bay cellars being at grade 12, and the sewers keeping the water at grade 8, capillarity in gravelly soil will cause no undue amount of moisture to rise into the cellars. Some of the sewers discharging into the basin are much lower than grade 8. Consequently such, if retained, would be permanently flooded by a permanently filled basin. Others again that are higher would be benefited by being above the general basin level, instead of below high tide.

To have the ground water only 2 feet below the surface of the pres-

ent marshes would be sufficient, if this territory is developed for park purposes and not for dwellings. The present marshes could be fairly well drained to this depth. For building purposes the ground would require several feet of filling should the constant water level be established. If the tidal flow in the basin is preserved and the marshes are diked, these can be drained by gravity to a lower level than practicable with a constant level at grade 8, and would be suitable for dwellings without filling.

Soldiers' Field, once partly marsh land, could be sufficiently drained to a constant water level of 7 or 8, without injury to the ground, by lessening the slope of the main outfall pipe. From a general inspection, I believe the same is true of the other marsh lands.

I do not fear the slightest injury to piles upon which many of the Back Bay buildings are placed, if the basin level were permanently reduced even to grade 7, because I understand the piles are cut below this elevation.

Two of the objects to be obtained by establishing a basin with a constant water level at grade 8 were to prevent the continually recurring flooding of the marshes at spring tide and the backing up of the high tide water into many sewers and cellars of the low districts.

It would appear to me that the avoidance of meadow flooding at every spring tide is a desirable object. It is entirely practical, however, to accomplish the same end with dikes, irrespective of a dam across the river.

To prevent the backing up of water into some sewers in low districts, and flooding of cellars during heavy rains occurring at high tides, is also a commendable purpose, and could not be accomplished as readily by other means than by permanently reducing the water level in the basin to grade 7 or 6.

Summing up the evidence regarding the effects of a constant basin level of grade 7 to 8, it does not appear that, because prevented by sewerage, the ground-water level would anywhere be materially raised thereby, nor would it be lowered except on the salt marshes which are now flooded at spring tide. Here, by avoiding partly the semi-monthly flooding and the semi-daily fluctuations, the ground-water level would be lowered sufficiently to make such marshes useful at least as park meadows. Diking these meadows would make them available also for building purposes, but pumping out the ground water would then become necessary if a dam is built.

Whatever sewers now discharge into the basin below grade 8 would be permanently flooded. As none but storm overflows, after having all their foul water intercepted, should, in my opinion, be allowed to discharge into the basin, their submergence would not be an evil. If submerged and filled with foul water, they would be quite objectionable. Permanent submergence in any case, however, prevents an occasional inspection, and is to this extent undesirable.

D. — Lowering of Water Level above Dam to receive Freshet Waters and permit Flushing.

The building of a dam and the maintenance thereby of a general water level, about 2½ to 3½ feet below mean high tide, requires a careful consideration of the effects, should there be a flood in the river.

Mr. F. P. Stearns believes that a provision for the flood waters at the rate of 6,000 cubic feet per second, extending over at least one complete tide, is sufficient. He bases this conclusion on the actual flood discharge observed during the storm of February, 1886.

Mr. A. H. French, in his testimony given in 1894, inclines to the belief that 10,000 cubic feet per second would be a more correct figure. The water from this flood should be stored, he says, during four hours of high and receding tide, and requires a depth for storage of 4 feet over the entire basin.

Prof. Dwight Porter states that under unfavorable conditions the basin could not be lowered, in preparation for a freshet, to a level below grade 6, because of low tides, which have been observed during storms, remaining as high as grade 5. He further believes that flood storage should be provided for a flow of not less than 7,000 cubic feet per second, on the supposition that the maximum flood wave at Waltham, coming from the large water-shed above, might combine in the basin with a discharge from the smaller water-sheds of Stony brook and other territory sufficiently near the maximum flow of the latter to give this resultant value.

After a careful examination, I am of the opinion that a flood wave as large as 7,000 cubic feet per second might occur at rare intervals in the future. In such a case, Professor Porter has computed, the basin level, if lowered to grade 6, would rise to about grade 10, which result I have also reached approximately. It might, therefore, be remotely possible that, should a dam be built, a slight flooding of a small area of the meadows would occur, unless they should be diked by roadways skirting the river.

An extraordinary high tide, such as occurred in 1886, when it rose to grade 15.66, gives but a brief warning, though naturally held back by the dam; while a flood in the Charles River gives at least one day's warning, during which time, however, there must be not the slightest neglect in making provision to lower the basin and protect property.

It is necessary to use great skill in operating the gates and in drawing down the water to a stage which is justified by the flood warnings from the upper valley. In addition, as said above, it is necessary to operate storm-water pumps, to prevent sewage and street water from entering the basin. A sufficient staff of men, well trained for the several contingencies, is therefore an imperative adjunct to the proposed undertaking.

Regarding the navigation of the Charles River, Professor Porter has collected evidence which throws much light upon the same. There can be no question that the existence of a dam would retard the passage of vessels, and reduce their draft if not entering at high water. The season for navigation would also be shortened by the better opportunity for a freezing up of the basin and of the river below. On the other hand, with a lock and a constant deep-water level, navigation becomes practicable also at low tide stages, which now it is not.

The question covering the occasional lowering of the water in the basin for the purpose of partly replacing it by salt water, after a long summer drought, has already been answered. If the basin were ever to be emptied to extreme low-tide level, the banks would require protection against sliding, just as much, and to the same depth, as would be required were no dam built.

If the water were never lowered below mean tide, or grade 5.4, a marked saving of expense both in shore protection and dredging could be secured; and no good reason appears why the water level should ever be drawn below grade 5 or 6.

In the absence of such a reason, it has been suggested to build a so-called half-tide dam at this elevation. The chief advantage of the same would be a continuous water covering of the offensive flats, and therefore of their disappearance, at a smaller expense than can be secured

by any other of the proposed improvements. The half-tidal dam would be quite effective for this purpose. It would somewhat resemble the one built across the Thames at Richmond, above London, which secures a minimum depth at low water of 5 feet 9 inches where boats could not travel before.

A movable half-tide dam would permit the discharge of a somewhat greater percentage of overflowing street water into the Charles River, without giving offensive results, than either the high dam with a pool at grade 8, or the present free tidal flow with exposed flats. It would also permit salt water to enter the river, and preserve all of the advantages due to such water. It would not interfere with the discharge of flood waters nor with navigation as much as a high dam. Its chief merit would be that it creates a marked improvement in the basin, by abolishing the exposure of the mud flats, and reduces also the shore area exposed between tides, — otherwise it would not materially alter the present conditions. Its expense would be much less than that of the high dam, not to speak of other expenses required to keep the constant level pool in a suitable condition.

In summing up the facts under the present heading, while there appear no serious difficulties so far as freshets are concerned, there is the constant vigilance necessary of guarding against undesirable contingencies when operating the works at the dam.

Injuries suffered by navigation, so far as they exist, would have to be adjusted by money payments.

The building of a movable dam up to half-tide level would overcome most of the trouble now complained of, and would be much less expensive than a dam extending above the highest tide.

E. — Treatment of Fens Basin.

It is admitted that the Park basin located in the Back Bay Fens is not at all times in a desirable condition for a park. It receives its water from the valleys of Muddy River and Stony Brook. These valleys occupy over 14 square miles of land, and are becoming more and more populated. Sewers have been built which discharge their overflow water into these brooks whenever rainfalls exceed the capacity of the intercepting sewers.

In dry weather the flow of these streams is too small to safely receive such a discharge of overflowing sewage, particularly when this enters a pool of about 30 acres area, and is given a very slight velocity at nearly all times. It is stated that this velocity, which sometimes becomes nil, has caused a deposit of 30,000 cubic yards of mud and sewage sludge between the years 1889 and 1897; consequently, the condition of the Fens is offensive in hot weather, and not wholly satisfactory at other times.

As this condition is the result of allowing the overflow from sewers and the surface wash from streets to flow into the Fens, it points clearly to the similar condition that may be expected, although to a less degree, in the Charles River, with its sewage overflows and surface washings, during the latter part of the summer season, flowing into a pool generally stagnant at its shores. The natural flows from Muddy River and Stony Brook are too small to prevent mud from depositing in a basin which is so much greater in cross-section.

If this unsatisfactory condition of the Fens basin is to be prevented, it is necessary to establish artificially a greater circulation through it than exists at present.

Should a tidal flow continue in the Charles River, it is possible to

obtain a better circulation by an inflow of river water at high tide through a special conduit from the river to the present dam in the Fens, and a gravity outflow through the Fens back to the river at lower stages of the tide.

Should a tidal flow be discontinued, it has been suggested to place a propeller wheel at the Fens and Brookline Avenue, to draw a sufficient quantity of water from the river through the existing conduit, and to deliver it at an elevation so as to let it circulate through the Fens to the river basin.

A solution is, therefore, given for either case. The chief difference will be a matter of cost.

F.—Alster Basins.

In support of the proposition to establish a fresh-water basin in the Charles River, the Alster fresh-water basins in Hamburg have been prominently mentioned as a precedent. More than six years ago Mr. C. O. Gleim, corresponding member of the American Society of Civil Engineers, contributed some remarks and plans to the Massachusetts State Board of Health, describing the Hamburg basins. My own personal knowledge, gained during a residence of several months in Hamburg and a recent correspondence with Mr. Gleim, together with a report recently received from Dr. Dunbar of the Hygienic Institute in Hamburg, may throw further light upon the matter.

As the question of salt *v.* fresh water never was raised in the Alster basins, because they are far above salt-water influence, a comparison must be confined to the effects of a large fresh-water lake in a populous city under the topographical and climatic conditions of Hamburg and Boston.

I have attached two tables, showing comparative physical data, which will explain themselves. It will be noticed that the water-sheds are not very different in area; deducting the diversion into Mother Brook, the Charles River has somewhat the smaller one. The rainfall in the latter water-shed is about double that in the other. The mean flow per square mile is about two and one-half times greater for the Charles River water-shed than for the Alster water-shed, indicating a slightly better run-off in our case. The ordinary dry-weather flow is about the same per square mile of water-shed, in spite of the difference in rainfall, and is due to the more uniform seasonal distribution of the rainfall in Holstein than in Massachusetts, and also due to better ground facilities for retaining and storing both the surface and subsoil water.

Comparing the temperatures, it will be noticed that the average monthly means are nearly the same, but that the extremes differ considerably. The average monthly maximum is nearly 13 per cent., and in September nearly 30 per cent., greater than in Holstein. The average monthly minimum is almost 30 per cent. less; in January and February the minima for each month being respectively, 10.2 and 15.1 degrees for Holstein, and —4.5 and —7 degrees for Massachusetts. Throughout every month of the year the relative humidity is about 11.6 per cent. greater, on the average, than in Massachusetts.

We may conclude, from the greater temperature extremes, that the conditions as regards the effects of decomposition and putrefaction of the sewage matter in summer weather will be somewhat more aggravated in Boston than in the Alster basins, and that, therefore, greater precautions would be necessary.

The average velocities over the mean cross-sections of the two basins indicate that the ordinary summer flow in inches per minute would be 1.8 in the Charles River and 4.3 in the Alster basins. At the shores

these velocities would be even less. The general summer velocities in the present case would therefore be but about one-half of those in the basins of our precedent; the extreme minima, so far as we know, would be about alike, although these are somewhat uncertain and only rough estimates.

The higher summer temperatures in Boston would cause a greater evaporation than in Hamburg. It is probable that about one-eighth of the entire ordinary dry-weather flow and about one-quarter of the minimum would thus be lost in the proposed water park.

In 1898 the Hygienic Institute of Hamburg was requested to examine into the question as to whether a separate system of sewerage, with a discharge of rain water into the Alster basins, was permissible. Interesting examinations were made, with the conclusion that a discharge of "the polluted rain water from drains of the separate system into the Alster basins should be looked upon as being irrational and suspicious."

No rain water from street surfaces is allowed to enter the basins, and in a comparison of the effects obtained in the Alster with those expected in the Charles River basins, this fact should not be ignored. Dr. Dunbar, in explaining the situation and his conclusion, gives some interesting information, as follows: —

The principal streets of Hamburg are cleaned by machine sweepers daily; the principal side streets twice a week, and the rest once a week. Certain streets are also cleaned by flushing.

The streets which have good pavements are generally cleaned completely by heavy rainfalls. No definite information has been obtained regarding the least height of rainfall to accomplish this cleaning. Trials with artificial flushing on asphalt pavements have shown, however, that a height of 3½ mm. suffices when applied in 10 minutes. The personal observation and judgment of Dr. Dunbar leads him to the opinion that in Hamburg a rainfall of 5 mm. should be expected to clean a well-paved street.

Assuming that a rainfall of at least 5 mm. will remove the street dirt that has accumulated in 1½ days, and that one of 3 to 4 mm. will remove half this quantity, then it may be concluded, from careful tabular compilations attached to his report, that in one year 11,025 tons of horse dung, and about double this amount, or 22,050 tons, of detritus is washed into these sewerage works.

As some of this matter remains in the catch-basins, he concludes that annually about 10,100 tons of horse dung, or its equivalent, and 20,200 tons of detritus, are carried through the sewers of Hamburg into its water sources.

Appendix III. of Dr. Dunbar's report gives analyses of the street water taken from gutters when entering the catch-basins, and they show that the amount of putrescible matter is greater than is generally supposed, even on streets with moderate traffic.

Appendix IV. gives analyses at the same points, but at different periods of the storms. From these it is concluded that only the most intense rainfall gives the streets a thorough cleansing in a short time. Within the first hours of an ordinary rain this is not the case in Hamburg. Applying this information to Massachusetts, where we have frequent heavy showers, we may conclude that such a complete cleansing of the streets would result more frequently than in Europe.

The chief affluents feeding the basins are the Alster, the Little Eilbeck and the Osterbeck. In 1875 the mean daily flow of the Alster was computed to be 300,000 cubic meters. After a protracted drought the flow has been estimated at 30,000 cubic meters per day. The other

affluents are small. There is no knowledge regarding the ground water entering the basins.

In 1875 it was stated that annually 112,000,000 cubic meters were withdrawn from the basins for various purposes. This would correspond to a renewal of the water in the basins within 14 days. The maximum flow was estimated at 7,000,000 cubic meters per day, corresponding to a renewal in less than one day. Dr. Dunbar therefore concludes that during certain periods a renewal will require much longer than 14 days. At dry periods, the surface water, even ignoring evaporation, cannot replace the water in the basins in less than 100 days, should the dry period last so long.

From what has been said, it is necessary to consider the water in the Alster basins practically as stagnant. In the attached Table I. a comparison is given between the velocities of flow in the Alster and Charles River basins.

The overflow water from the sewers discharging into the Alster basins, as Dr. Dunbar says, would soon come to rest, and deposit its mud. This is actually now the case in several instances.

A thorough mixture of the overflow sewer water with the Alster water does not take place. It often remains near the discharge points in comparatively great concentration until the foul matter has settled.

Dr. Dunbar's examinations have indicated that the street water, when mixed with Alster water in the proportion of 1 to 5, has an unpleasant odor. The water flowing from streets with heavy traffic, when mixed in the proportion of 1 to 20, had a foul odor even after 7 days.

The transparency of the Alster water, measured by a visual scale, sinks from 40 cm. to 10 cm. after rains, and rises again to 30 cm. after 24 hours' settling. When mixing 1 part of the street water with 100 parts of Alster water, the transparency ranged, according to different samples, from 5 to 10 cm. on the first day, and from 6 to 17 cm. on the following day. When mixing 1 part of the street water with 20 parts Alster water, the transparency ranged from 1.7 to 7 cm. and, even after one day's settling of samples taken from frequented streets, had a transparency of only 2.4 cm.

The evidence from the Alster basins is therefore not favorable to the creation of a water park on the Charles River under the provision that the overflow from sewers of a combined system, or even the discharge of the water from storm drains of a separate system, is introduced. It justifies the opinion expressed above, — that not only all the sewage, but also the first wash of rain water, from streets, to the extent of at least one-eighth of an inch per hour, and perhaps double this amount, should be excluded from the proposed water park.

In the evidence of this case I notice that Mr. J. E. Abbott alludes to the Schuylkill River basin at Fairmount, Philadelphia, as a precedent for the assertion that a pool almost stagnant at times can have water pure enough to furnish a city with a domestic supply without producing harmful results. This statement is misleading. The water obtained from this river for the city's use has produced very harmful results. It contains the sewage of the population spread over a large portion of the valley, and is the well-known cause of the high rate of typhoid fever prevailing in Philadelphia. Efforts have been made for many years to obtain a new water supply, resulting at present in the construction of large filter works. Although in dry weather no water flows over the dam, the pool is not stagnant to the degree which prevails in the Alster basins or would prevail in the Charles River, because its entire minimum flow of 150,000,000 gallons daily has been abstracted for the city's use above the dam, and for that reason often left nothing to pass

over it. The malaria which prevailed near the Fairmount pool for many years has now practically disappeared, because the shores have been improved, the bordering swamps filled up and the favorable habitats of the mosquito removed.

Conclusions.

A retrospective glance over the facts and opinions stated above and elsewhere concerning the probable effects of building a dam across the Charles River within its tidal reach, and of sufficient elevation to exclude tide water, forces upon me the following general conclusions: —

Should a dam be built, its most desirable location seems to be in the narrow portion of the river near Craigie bridge, rather than near Cottage Farm; the former site is therefore the one here especially considered.

The chief advantage claimed for this dam is an æsthetic one, — the creation of a fresh-water lake of constant level, with surrounding park, somewhat resembling the Alster basins.

To secure this advantage, with a proper regard for the future local requirements of a metropolitan park, it will be, in my opinion, necessary to comply with certain demands. The most important of these is a much more radical interception of the foul matter naturally entering the basin than has originally been proposed.

It is necessary, in my judgment, to divert the overflow water from the present combined sewers, as well as the water from special surface-water drains in a separate system, into intercepting drains, one built on each side of the river, which should discharge below the dam. The capacity of such drains should be sufficient to carry an amount of water not less than one-eighth inch in depth of rain per hour flowing from the respective drainage areas. This figure might perhaps be sufficient if the separate system of sewerage prevails, and surface water alone enters the drains, without the constant admixture of house sewage during the continuance of a rain. This interception of surface water should begin as far up the river as its pollution requires; in other words, as far as the built-up city territory extends. The point of discharge should be some distance below the dam, sufficient to secure the dispersive effect of the tidal flow. Provision would be required for pumping this water at the dam, except at times of low water, when it might flow out by gravity. The silt introduced into the river, as well as that which would otherwise accumulate immediately below the dam on account of the cessation of tidal oscillation, would by its deposit require periodical removal by dredging.

The displacement of salt water, with its pleasant and invigorating influence and its lower temperature, the injury to navigation by lock detention and greater ice accumulation both above and below the dam, are further disadvantages resulting from the construction of a dam, all of which must be compensated by greater advantages, if this project deserves the preference.

The evidence regarding disease transmission, being substantially confined to malaria, is not strongly in favor either of a salt or a fresh water basin. The preponderance of evidence somewhat favors the former. In either case, it is necessary to pay great attention to the proper construction of the shores, and to the vegetation that may be allowed to grow to the water's edge. It is also important to exclude from the water as much as possible all nitrate-producing matter, in other words, sewage, and thus reduce the quantity of nourishment for the aquatic plants among which mosquitoes thrive, as the transmitters of the malarial protozoa.

The effect upon the ground-water level of a dam, which holds the surface at or near grade 8, will be to lower it in the tidal marshes. On the higher ground, which may contain residences and sewers, the ground-water level can be influenced by the grade of the latter.

With a dam built across the river, storage must be provided above the dam sufficient to hold the water of the greatest freshets during the highest tides, and thus prevent injurious flooding of the park and other lands bordering the river. It will be necessary to receive a warning of such floods in time to lower the water in the basin during the first succeeding low tide. Great care and vigilance would be required to properly operate the discharge gates at the dam, so as to avoid serious damage to land when not prepared for it.

A dam will necessarily injure the present navigation interests to some extent, which will require compensation by money payments.

The Fens basin could be improved and made satisfactory either with or without a dam. Here the preference may also be measured by the cost.

A comparison between the existing Alster basins and the proposed Charles River basin, based on hydraulic and sanitary evidence, is not favorable to the latter, unless all of the sewage, and also the first rain-water wash from frequented streets, is kept out of the basin. Even then there may be times when the water in the Charles River basin would be more stagnant than in the Alster basins.

In order to secure the æsthetic advantages of the proposed park, without introducing new conditions that would be objectionable in one way or another, it is necessary, besides building the dam, with its locks, gates and machinery for operating the same, to build also drains to keep out of the basin all the overflow sewage, the first rain-water wash from frequented streets, and the refuse from manufacturing establishments on the Charles River above the metropolis. It is also necessary to provide shore protection around the proposed basin, to dredge out some of the flats, and to provide machinery for establishing a better circulation in the Fens basin. Besides this construction work, it will be necessary occasionally to dredge silt and refuse deposits from the basin, and also from the river below the dam, and the harbor.

The effects of the dam are therefore wide-spreading, embodying numerous risks, which require the most careful operation and management of the works, and also large expenditures of money.

The entire cost of constructing and maintaining the proposed works should be carefully ascertained along the lines above discussed. Only then will it appear whether or not the price to be paid for a park that is wholly above suspicion is justified by the advantages to be gained over and above those that would be lost by abandoning the present tidal flow.

If this price appears too great, then it seems that the proposition of a half-tidal movable dam would overcome at least the chief objections due to present conditions, and this at a much smaller cost. Such a low dam would, by the removal of the unsightly bottoms and material reduction of the large breadth of shore exposed at low tide, increase the value of the shore property, both for park and residence purposes. It would keep the flats under water at all times, and permit salt water to enter the basin as at present. Diking the marsh meadows could prevent their overflow during highest tides, and secure their usefulness for park and building purposes to the same extent as would be done by the high dam.

So long as the basin is converted into a park, with the expectation of having ornamental shores, the necessity for a better disposal of the

overflowing sewage and street water than at present contemplated would still remain. But it would not be necessary to carry this intercepted water to points below the half dam. It is possible to obtain a thorough dispersion in the basin by the greatly increased tidal flow, if the overflowing water after storms should be carried far out into the basin by submerged pipes, and discharged near its bottom. It also appears advisable to prevent all floating matter from entering the same, by providing suitable screens on shore.

The shipping interests on the river would find low-water navigation improved, while high-water navigation would remain practically the same. The effects upon the harbor would be an improvement over those resulting from a high dam, because of the maintenance of a greater scouring force.

Respectfully yours,

RUDOLPH HERING.

TABLE I. — *Comparison of Certain Hydraulic Data of the Water-sheds of the Charles River (Mass.) and Alster River (Holstein).*

	Alster River Water-shed, at Hamburg.	Charles River Water-shed,* at Lower Watertown Bridge.
Drainage area, in square miles,	230	204
Average annual rainfall, in inches,	23	45.8
Mean flow, in cubic feet per second,	150	340
Mean flow, in cubic feet per second per square mile,	.65	1.67
Ordinary dry-weather flow, in cubic feet per second,	70	62
Ordinary dry-weather flow, in cubic feet per second per square mile,	.33	.33
Minimum flow, in cubic feet per second,	15	31
Minimum flow, in cubic feet per second per square mile,	.065	.15
Area of basins above dam, in acres,	475	758
Capacity of basins above dam, in cubic feet,	134,000,000	440,000,000
Capacity of basins above dam, in gallons,	1,100,000,000	3,300,000,000
Summer maximum rate of evaporation from water surface, in inches per day,	.22†	.25
Equivalent evaporation, in cubic feet per second,	4.4	7.9
Mean velocity through basins for ordinary dry-weather flow, in inches per minute,	4.3	1.8
Mean velocity through basins for minimum flow, in inches per minute,	.9	.9

* After deducting 66 square miles, which may legally be diverted into Mother Brook.
† Estimated.

TABLE II. — *Average Monthly Temperatures, in Degrees F., and Relative Humidity, for Holstein and Massachusetts.*

	MONTHLY MEAN TEMPERATURE.			MEAN MAXIMUM TEMPERATURE.		MEAN MINIMUM TEMPERATURE.		RELATIVE HUMIDITY.	
	Holstein.*	Mass.†	Mass.‡	Holstein.	Mass.‡	Holstein.	Mass.‡	Holstein.	Mass.§
January, . . .	33.4	24.1	24.4	48.2	52.0	10.2	—4.5	89.9	72
February, . .	34.7	25.8	23.7	50.4	58.0	15.1	—7.0	87.3	68
March, . . .	39.0	32.2	29.0	58.1	52.5	21.4	3.5	83.7	61
April, . . .	46.7	43.9	45.3	69.1	75.0	28.6	23.5	75.4	61
May, ...	54.1	56.3	54.4	78.8	91.0	34.7	27.5	70.9	68
June, ...	61.3	66.0	67.5	83.3	91.5	43.7	39.5	76.9	67
July, . . .	64.0	71.4	71.5	88.7	96.0	48.6	49.5	79.3	67
August, . . .	63.1	68.6	70.0	84.9	93.0	48.6	46.0	80.1	76
September, . .	57.7	60.8	63.9	76.5	99.0	41.9	33.0	83.0	77
October, . . .	49.6	50.1	55.9	65.3	79.5	32.0	27.5	85.4	83
November, . .	39.4	39.0	40.5	54.0	67.0	22.3	16.5	87.5	81
December, . .	35.4	28.5	28.1	49.3	55.0	14.7	1.0	89.9	75
Average, . .	48.2	47.2	47.9	66.8	75.8	30.1	21.3	82.5	71

* Hamburg, in "Naturhistorischer und Medicinischer Beziehung," by F. Andreas Meyer und J. Reincke.

† Massachusetts State Board of Health report, "Examination of Water Supplies," 1890.

‡ Clinton, from report of Metropolitan Water Board of Boston, 1901.

§ Monthly Weather Review, United States Department of Agriculture, 1900.

DEE CONSERVANCY BOARD.

BOARD OF TRADE, FISHERIES AND HARBOR DEPARTMENT,
7 WHITEHALL GARDENS, LONDON, S. W., June 20, 1902.

SIR: — In continuation of the letter from this department of the 5th ultimo (H. 5433), relative to the construction of dams across tidal streams in Great Britain, I am directed by the Board of Trade to transmit to you, herewith, copy of a letter and relative enclosure received from the clerk to the Dee Conservancy Board respecting the dam or weir across the River Dee at Chester.

I am, sir, your obedient servant,

THOS. PELHAM.

R. H. DANA, Esq., *Room 203, 14 Beacon Street, Boston, Massachusetts, U. S. A.*

OFFICES OF THE DEE CONSERVANCY BOARD,
ABBEY GATEWAY, CHESTER, June 12, 1902.

SIR: — Adverting to your letters of the March 17th and 9th instant, I beg to send you enclosed a statement which the Acting Conservator of my Board has to-day sent me, and which, to save time, I pass on to you direct, asking you to be good enough to understand that it has not been submitted to the Board, and therefore must be taken as coming from the Acting Conservator, and not from the Board or myself.

I am, etc.,

SAM SMITH,
Clerk.

The Assistant Secretary,
Fisheries and Harbor Department, Board of Trade.
7 Whitehall Gardens, London, S. W.

MARCH 22, 1902.

Reply to Board of Trade Letter, asking for Information in Respect to a Dam erected across the River Dee within the Jurisdiction of the Dee Conservancy Board.

There is a dam or weir across the River Dee at Chester. The river at the point where the weir is fixed is 200 feet wide, and has a perpendicular height from low water to the crest of 8½ feet. The weir has the effect of forming a basin above of about 7 miles in length at ordinary tides and 14 miles at high spring tides, and shuts out the tidal water from this basin during the former.

Spring tides flow over this weir about 200 times in a year, varying in height from a few inches to 5 feet. The average rise of tide at

Chester is about 12 feet, so that, except for the greater width of the Charles River, the conditions of the Dee are very similar.

The dam has been in existence for hundreds of years, and the following old account gives its early history as far as known: "This dam was erected by the Earl of Chester, Hugh Lupus,* who also made a diversion in the course of the river, and brought it nearer to the town previous to the conquest. Henry III. subsequently becoming Earl of Chester, the mills reverted to the Crown, and were attached to it until Edward VI.; and in the sixth year of that reign they were granted in fee to Sir Richard Cotton, and subsequently to his son, who again let them at £100 per annum to Edmund Gamul, who afterwards expended £4,000 on the repairs of the dam or causeway, a considerable sum in any case, and more particularly so at that early period. In the following century (seventeenth), the dam or causeway became a subject of much litigation, in consequence of its supposed prejudicial effects on the river, by its preventing the free access and discharge of the tidal and upland waters, and thus preventing them from cleansing and scouring the harbor from the accumulating sands."

There does not appear to be a record as to whether any alteration was made to the dam in consequence of the litigation referred to, but the latter part of the quotation would seem to indicate the engineering opinion of that period.

In the middle of the eighteenth century a very great alteration was made in the course of the river below the weir, and this circumstance, combined with the absence of any accurate data as to the state of the river before the erection of the weir, makes it impossible to definitely say how its construction affected the navigation.

In recent times, methods for the improvement of the navigation of the River Dee have been reported on and carried out by many eminent engineers, commencing with Mr. Telford in the early years of the nineteenth century. It is not certain that interference with the weir at Chester was contemplated until 1849, when it was suggested that the river would be greatly improved if the weir were taken down, and since that time it has frequently been stated by some engineers that much benefit to the navigation would result if the weir was taken away.

This is not the opinion of the engineer to the navigation, Mr. Enfield Taylor, M. Inst., C.E., of Chester, who has studied the effect of the tidal dam across the Dee and similar ones in other rivers for over thirty years.

The effect of removal would be to ruin the beautiful basin of almost still water (which is immensely enjoyed for boating), and turn it into a shallow, muddy-smelling stream at low water, while also a most valuable water power would be lost forever.

The Dee engineer's view is that all tidal dams should be under control of the navigation authority below; and that, by systematic management, not only can the pure land water be held up for domestic supply and boating purposes, but the power preserved and the sluices manipulated so that when scour is required, viz., in times of drought and low tides, it will be provided in the form of artificial floods.

The Chester weir is constructed of stone.

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* His reign as Earl of Chester commenced A.D., 1070.

CLYDE NAVIGATION. — WEIR AT GLASGOW.

The following statement in reference to the tidal weir at Glasgow was sent to the committee on Charles River dam by Thomas Pelham, assistant secretary of the Fisheries and Harbor Department of the Board of Trade, London: —

The tidal weir which was finished at Glasgow in December of 1901 is constructed with Stoney sluices, and follows the general ideas of the weir across the Thames at Richmond.

This is the fourth weir which has been constructed across the Clyde at different positions. When the first weir was made is a point on which there is some uncertainty, but the work would appear to have been taken in hand about one hundred and thirty years ago, when the magistrates and council of the city, the then Clyde trustees, caused a number of large stones to be thrown into the river around the piers of the old Jamaica Street bridge, to strengthen them, in consequence of the signs of instability that were becoming manifest owing to deepening operations for navigation purposes. Towards the close of the eighteenth century, in the year 1799, John Rennie reported regarding obstructions in the river near the new bridge, and gave it as his opinion that, if the weir were entirely taken away, the bridge would be endangered.

In 1836 steps were taken to further deepen and enlarge the harbor, and open up the river beyond the Broomielaw; operations that meant the removal of the weir, an event that took place six years later, at the instance of the Clyde trustees and the burgh of Rutherglen. The site of the new structure was fixed on the east side of the old Stockwell Street bridge. The requirements of the water company had next an effect on the site, and in 1851 the third weir was built, on the east side of the Hutchesontown bridge, which spanned the Clyde at the foot of Saltmarket, where the Albert bridge now stands, for the passage of barges. It was provided with a lock 74¼ feet long and 25 feet wide, and a durable pair of gates, having a depth of 8 feet on the upper sill and 12 feet on the lower at high water on average spring tides. Towards the sinking of the piers and reconstruction of this weir the Clyde trust contributed £19,000.

The proposal to remove this weir aroused a fierce controversy, and public feeling ran high; but the "removal" party carried the day, and in 1879 it disappeared. The effects of this retrograde policy were soon apparent. The influx of the tide carried the pollution of the harbor and the lower reaches into the upper reaches, while the liberation of the impounded water affected the tidal conditions to a serious extent, and vessels of deep draught were considerably delayed. Destruction of the river banks above the removed weir set in, and the excessive scouring of the river necessitated increased expenditure in dredging the river west of Jamaica Street bridge. The public health was menaced by the exposure of mud flats at low water, and a good deal of damage was done to boating, then a popular pastime east of Stockwell.

The corporation obtained power to spend £50,000 in repairing and strengthening the river foreshores along the entire extent of the river boundary; but before this sum had been exhausted the question of a new weir began to engage public attention.

In 1890 the Thames conservators, whose predicament was similar to that of Glasgow, obtained sanction to build a weir with movable sluices at Richmond. An examination of this work stimulated the Glasgow authorities to action, and they subsequently made an inspection of the sluices on the Manchester ship canal. That visit confirmed them in their former opinions as to the efficiency and reliability of the principle on which the action of the sluices depends; and they therefore resolved to advise the town council to support the scheme for the replacement of the weir, a considerable portion of the cost of which would be met by the money that had been authorized to be spent on repairing and strengthening the foreshores.

The sub-committee who had the matter in hand said they had no doubt that a new weir would greatly change for the better the general condition of the river, especially within the upper reaches. The erosion of the banks and the decay of the old river walls would cease, because the impounded water would restore the support which was taken away when the weir was demolished in 1879, and the unsightly tidal margin of the Green would disappear. The restoration of the former level would enable the citizens to enjoy the use of the river for boating, and the privileges would be vastly increased by the purification of the stream when the east-end sewage works came into operation. While the general public would enjoy a large degree of what might be regarded as æsthetic benefit, an unquestionable practical advantage would be conferred on the trustees of the Clyde navigation, and sea-going vessels, which were now delayed, would be able to leave so much earlier. It was claimed by the inventor of the sluices that the erection of the weir would induce a tidal change that would not merely bring up the float tide earlier, but would add nine inches to the depth of the tidal water.

The recommendation of the sub-committee was adopted, plans obtained, and after seven years the Clyde is to see its fourth weir in operation.

ARGUMENT OF ALBERT E. PILLSBURY.

In behalf of property owners and occupants on the Cambridge shore and the Broad and Lechmere canals, Albert E. Pillsbury submitted the following argument to the committee, Oct. 10, 1902: —

Mr. Chairman and gentlemen: In view of what has already transpired, it will be necessary for me to do little more than to explain the arrangement which has been entered into between the promoters of the dam and the property owners on the Cambridge shore. We recognize, of course, that agreements between the parties are not absolutely binding upon the committee, and it belongs to us to make such explanation as will enable the committee to see that the terms upon which we have agreed are reasonable and proper.

I am authorized to speak for all the property owners and occupants on the Cambridge shore of the Charles River between the Craigie and West Boston bridges, except the city of Cambridge, and all the owners and occupants of property abutting on the Broad and Lechmere canals. They are represented by a committee consisting of Messrs. W. A. Hunnewell and J. F. Wellington, dealers in coal, and Mr. A. M. Barnes, treasurer of the Cambridge Gas Light Company. We shall file a tabulated statement, showing the character and magnitude of these interests.

In view of the agreement which has been reached, I had not considered it necessary to go into the history of the canals, or the rights or titles of the abutters; but it has lately been intimated to me that the committee would like information in this direction.

Broad canal originated under an indenture of July 8, 1806, between Henry Hill, Rufus Davenport and others, owners of lands and flats in that vicinity, laying out a system of docks and canals, of which Broad canal now alone remains. It defines the boundaries of Broad canal, 80 feet wide from low-water mark to Portland Street. The fee in the bed of the canal is released to the parties in common, in proportion to their several interests, under a previous agreement therein

referred to; with stipulations that each subscriber, and certain other owners in the vicinity who should become subscribers, and the successors in title of all of them, "shall have a right to enter into, go out of and pass over and through any and all the said canals and docks with vessels, boats and rafts and other things, and the same to lay and fasten in one tier, rank or row, to wharves and landing-places on their respective lots, subject to removal so as always to keep a free passage through the said canals and docks;" with provisions for the filling of the abutting lots at a prescribed slope, and the dredging of the canal between the slopes. It does not appear from the indenture that the owners on the northerly side have title in the bed of the canal, but these lands appear to have been conveyed by the later deeds with the right of use and navigation of the canal, in common with other abutters, as appurtenant thereto.

The rights of the owners of the canal under this indenture have been enforced by the courts in Page *v.* Young, 106 Mass. 313; and Boston Rolling Mills *v.* Cambridge, 117 Mass. 396. In the report of the latter case it is said that "Broad canal was dug out, as located, before 1810, and has ever since been used for the purpose described in the indenture." The lower part of the canal, from a point between First and Third streets, is now 100 feet wide, and this width is recognized, if it was not originally fixed, by the action of the Harbor Commissioners, July 24, 1874, in licensing James A. Woodbury and others to fill their flats lying between the Broad and Lechmere canals; which required the licensees to construct a bulkhead and sea wall along the northerly side of the canal from the premises of the Cambridge Gas Company which adjoin Third Street, to a point twenty feet west of the Harbor Commissioners' line, and thence northerly to the Lechmere canal. The present bulkhead and sea wall along the northerly side of the lower part of the canal were probably built under this license.

The original trunk of the Lechmere canal appears to have originated under several deeds of Oct. 27, 1834, of lands and flats on the northerly side of it, from the Proprietors of Canal Bridge, a corporation chartered by an act of Feb. 27, 1807. These lands are conveyed "together with the privilege of a dock 100 feet in width on the south-westerly side of the aforegranted premises; said dock to be kept open forever for the common use and benefit of the owners and occupants of the land or wharves on either side and at the head thereof." The lots conveyed are bounded "by said dock," and the side lines run to it.

The southerly branch or extension of the Lechmere canal, as it now is, appears to have originated in the action of the Harbor Commissioners on the application of James A. Woodbury and others, July 24, 1874, already referred to; which reserves this space or channel, 120 feet wide, extending southerly from the Lechmere canal about 900 feet, out of the lands or flats to be filled. It has since been extended to Bent Street by Mr. Scully, the present owner of most of the lands in that vicinity. Such conveyances as have been made upon it include the right to have it kept open for navigation.

It thus appears that each canal is a navigable tidal waterway, in which all the abutters have common and permanent rights of navigation. The fee in the bed of the Broad canal is in some or all of the abutters in common. It is not clear that the fee in the bed of the original trunk of the Lechmere canal is in the abutters; if not, it appears to be in the Proprietors of Canal Bridge or their successors. The fee in the bed of the southerly branch or extension of the Lechmere canal is in the abutters in severalty, the title of the owners on each side extending 60 feet into the canal, to its median line.

As each canal appears to have been originally a reserved channel through or over flats which, while private property under the Colony ordinance of 1647 and the rule of Commonwealth *v.* Alger, were originally submerged by tide water, the owners, as between themselves and the public, undoubtedly have the common rights of riparian proprietors on navigable tide waters, with such other rights as the action of the Commonwealth or the United States has from time to time expressly or by implication conferred. All action of both governments down to this time has recognized and preserved the rights of navigation in the Charles River basin as an arm of the sea, and in the canals; except so far as navigation above West Boston bridge is now impaired by building the new bridge without a draw; and upon this privilege Congress imposed, by the act of March 29, 1900, the condition that the State should make compensation to the owners of wharf property above the bridge. As large sums have been expended in improving the canals, and large investments made on the faith of the action of the State and Federal governments, it may now be beyond legislative power to destroy or seriously impair these rights of navigation, at least without making full compensation. The owners would not submit to such a proposal, and it may be assumed that neither Congress nor our Legislature would entertain it.

It may be said, briefly, that there are forty-six separate estates directly affected by the scheme, that is, abutting directly upon the water and necessarily affected, comprising 2,501,265 feet of land, assessed at $1,257,600 for the land and $696,400 for the improvements, being a total assessed valuation of $1,844,000.

There are ten separate concerns receiving coal, six receiving lumber and thirty receiving stone, marble, piles, oil and other merchandise.

The annual amount of coal handled at these wharves, under normal and ordinary conditions, on the basis of the last available year, is about 264,000 tons, of the value of $1,213,-500; the annual amount of lumber is 38,500,000 feet, of an approximate value of $662,000; 200,000 barrels of oil, at $275,000; 78,000 tons of stone and marble, at $98,500; 50,000 piles, at $125,000; and other materials valued in the statement at $87,500. The total annual value of merchandise handled is not less than $2,461,500; in round numbers, two and one-half millions.

Some of the principal concerns there are the Barbour Asphalt Paving Company, the Bay State Fuel Company, the Wellington-Wild and Coleman coal companies, the Boston Woven Hose Company, the Page Box Factory, the Cambridge Gas Light Company, the Cambridge Electric Light Company, the Standard Oil Company, John T. Scully, who is the largest land owner, and others perhaps of equal importance.

Mr. Elliott, the engineer of the Cambridge Electric Light Company, has filed with you a report or statement containing valuable information, in which he says, among other things, that the water front comprised in these properties is about two and one-half miles, of which nearly two miles is actually occupied for commercial purposes. This two and one-half miles of water frontage affords the only direct access for water-borne freight to a community which may be conservatively estimated as not less than a quarter of a million people. He also notes the striking fact that whereas, in the year ending Jan. 31, 1894, the draw openings of Craigie bridge for vessels bound to points below West Boston bridge, that is, to the wharves between the two bridges, which I represent, were but 1,020, in the year ending Jan. 1, 1902, the number was 3,565, — an increase in eight years of 2,545 openings of the draw. And this, bear in mind, does not necessarily represent the number of vessels, which is undoubtedly larger, since more than one vessel may pass through the draw at a single opening, as they frequently do.

It appears that the commerce of these wharves has more than trebled within the last eight years.

Mr. Elliott has carried his investigation to somewhat wider limits. He has dealt with the whole territory between the river and the Boston & Albany Railroad, which, as he says, is almost entirely occupied for commercial and manufacturing purposes. It comprises about two hundred acres, upon which the business establishments have an assessed value of more than $5,000,000; and he estimates their annual trade to be over $5,000,000. It is undoubtedly much more. It is a poor business which in a year does not exceed the value of the plant. It would probably be nearer the truth to say $10,000,000 as the annual amount of this trade, rather than $5,000,000. And he also notes the fact that thirty years ago a great part of this territory was marsh and flats, unreclaimed, which the recent demands of trade and commerce have caused to be filled and built upon. In short, this territory is the seat of a large and rapidly increasing commerce, the benefits of which are by no means confined to the city of Cambridge.

To illustrate this, take, for example, the single item of coal. The coal which is delivered by vessels at these wharves is distributed through Cambridge, Somerville, Brighton, Brookline, Watertown and all that part of Boston near or contiguous to the river. It is estimated that two-thirds of all the coal consumed in this territory is furnished from these wharves.

Mr. Dana. The supply of Brookline and part of Boston must come from Cousen's wharf, at Cottage Farm.

Mr. Pillsbury. If Cottage Farm is not cut off from navigation by the building of the new bridge, the reasons against impairing the commerce of our wharves apply equally to that, and the argument is so much the stronger. As to the other third of the coal consumed in this territory, which comes chiefly from Boston, the price to the consumer is controlled by the price made on the coal distributed from these wharves, which the dealers are able to make by direct water access. In other words, no dealer can charge more for coal in this territory than the Cambridge dealers charge for the water-borne coal. It costs something like 75 cents per ton more to deliver coal there by rail than by water, and the facilities for the delivery of any large amount of coal in Cambridge by rail do not exist.

Colonel Mansfield. Isn't there a tax of something like 25 cents per ton on coal passing through the draw?

Mr. Pillsbury. There was at one time. It is now but

8 cents, being 1 cent per ton per bridge. But, notwithstanding all impediments upon the water-borne traffic, the wharves can make a better price there for coal than the railroads can. And the point I was making was, that no large amount of coal can be delivered there by rail, for want of facilities.

Mr. DANA. With reference to that, have you in mind the changes that the Boston & Maine are making in East Cambridge? They showed me a very large plan of delivery of freight there, which they said was going to give Cambridge an opportunity for freight which it never had before. They had a very large yard and track space, with room for teams between the sheds, and a new arrangement of tracks.

Mr. PILLSBURY. I have been speaking of the conditions which now exist. But I presume that the freight delivered there by the improved facilities, if they are created, will be railroad freight, which has paid the higher cost of the railroad haul. If there is, as I am informed, an advantage of 75 cents per ton in favor of water-borne coal over railroad coal, the consumer will get the benefit of it so long as the wharves are there, and no longer. If the wharves disappear, the railroad coal will no longer have to compete with water-borne coal, and the consumer will have to pay the added cost of the railroad haul. In other words, while the wharves are there, they fix the price, and it is the lower price of water-borne coal, whether the railroads deliver more or less.

I am informed that it is within bounds to say that the direct advantage to the consumer on the water-borne coal which finds access to this territory is not less than 25 cents per ton. This alone represents an annual saving to these communities, in the single item of coal, of not less than $100,000. The people of Cambridge and vicinity would have to pay $100,000 more for their annual supply of coal if it could not be received by water at these wharves. And, by the way, 25 cents per ton added to the price of coal adds 7 cents per thousand feet to the cost of gas, now sold in Cambridge and vicinity at $1 per thousand. Mr. Elliott says that the advantage on water-borne lumber is from $2 to $2.50 per thousand feet; on marble and stone, from $1 to $2 per ton; and so on. I call attention to these facts to show that there is an interest here much wider than the interests of the wharf owners or occupants. It is a public interest. It is of vital importance to these communities that these commercial facilities should not be disturbed or impaired.

When it was first proposed to dam the river, the attitude

of the property owners on the shore was unqualifiedly adverse to the project. It was evident, at a glance, that their property and their business were imperilled. A dam cuts off navigation. A dam, even with a lock, is an obstruction to navigation, and another burden laid upon it. There are other difficulties, incidental to the scheme, which cannot be wholly avoided. If the permanent water level of the basin is to be reduced to grade 8 above mean low water, that, at one stroke, will destroy navigation in these canals, unless they are deepened. They now have, at mean high tide, 16 feet of water, and they need literally every inch of it. Vessels drawing 16 feet can get up to the wharves at high tide, and no more. Grade 8 above mean low water is 1.8 feet below mean high water. In other words, a water level at grade 8 means reducing the water in the canals practically by 2 feet; and of course, if water navigation is to be preserved there, it is only by dredging the canals by way of compensation. The movement now is constantly toward vessels of larger draft, especially in vessels carrying such freight as coal; so that for the future, and indeed the immediate future, the depth of water must be such not only that vessels drawing 16 feet of water can get in there, but it should be more. The advantage is in bringing freight in larger vessels, and the movement of commerce is constantly in this direction, so that a depth of water which will do for to-day may not do for to-morrow or next year. The future must be provided for if these commercial facilities are to be preserved, or if the people of these communities are to enjoy the advantages which belong to water-borne freight.

Another serious difficulty is presented by ice, — already a difficulty sometimes serious, not frequently but occasionally, and one which will of course be aggravated in a still basin and a fresh-water basin, where ice forms more rapidly and freezes harder and deeper than in a tidal basin. If the basin has to be flushed from time to time, as undoubtedly it will be, perhaps to prevent the formation of ice or perhaps for sanitary reasons, that is another difficulty for navigation. In the present state of business competition, which has reduced profits to the narrowest possible margins, the commerce of this shore cannot bear these added burdens, and it is absolutely necessary to make provision to avoid them so far as it is physically possible.

There seemed to be three courses open to the shore owners. First, they could oppose the scheme *in toto*, in the hope of defeating it; second, they could abandon their property now used for commercial purposes, and insist that it be

taken by the public and paid for at the full; third, they could obtain such conditions, if physically practicable, as would allow them to carry on their business without any prohibitory burden laid upon it.

They turned toward the latter course, for a variety of reasons. In the first place, they did not wish to stand in the way, or seem to stand in the way, of anything which any considerable number of people regard as a desirable public improvement. Another reason for looking toward the third course is, that it is the only course which is in accord with the public interest against the destruction of that commerce, and in accord also with the views of the promoters of the scheme.

I ought to say that we have not made a careful investigation of this question from the engineering stand-point. We have employed no engineers on our own account, assuming that the committee, having expert talent at its command, would make all necessary investigation, or cause it to be made, and recommend nothing which would seriously imperil the commercial facilities of this territory.

It is due to the promoters of the scheme to say that they recognized the importance of these interests, the desirability of their continuance, and the impossibility of continuing them under any serious additional burdens. Meeting in that spirit, we have agreed with counsel representing the promoters, that, if the dam is to be built, it shall be built under certain conditions, in consideration of which we will withdraw the opposition to the scheme which otherwise we should be obliged to make for the preservation of our property and our business. Before presenting the agreement, let me say that we should very much prefer to be left as we are. We know the present conditions, and what we can depend upon. This scheme is necessarily to a great extent experimental. It is impossible to foretell with certainty what the conditions will be if it is carried into effect. There is a degree of uncertainty about it which is unpleasant to contemplate. But, from such information as we have been able to obtain, we believe that we shall be reasonably safe under the terms upon which, to avoid controversy, we have agreed.

Let me say, further, that Mr. Elliott has looked more closely into the details than we have from the engineering stand-point, and he urges some things beyond the conditions upon which we have agreed. We trust that the committee will pay due attention to his statement. It is quite possible that we have been too sanguine, and have not stipulated for all that we may need. For example, he thinks that the

lock should be wider and deeper than Mr. Blake proposes. He thinks, as we do, that it should be located in line with the draws of the bridges. These are important points, and it is not, of course, to be understood that we have bargained them away, nor anything else that is or may be necessary to the preservation of these commercial facilities unimpaired.

We have stated the terms with particularity. It was absolutely necessary that it should be so done. There is nothing here that can be dispensed with, — not a line, hardly a letter.

We have an estimate of the probable added cost of the dam which our conditions would involve. The estimated amount which full compliance with the conditions will add to what otherwise would be the cost of the dam, is not over $80,000, and I believe that estimate is from Mr. Blake. I do not wish to commit him to it in his absence, but I think he gave us that sum as his estimate of the added cost. The annual charge for that, at 4 per cent., which is more than the money will cost, would be little over $3,000; and I have already said that the annual saving to the community to which these wharves are tributary, in the single item of coal, is not less than $100,000.

If a dam is to be built, we much prefer to have it placed above us if possible, at or near the West Boston bridge. But we have assumed that the general opinion would favor the point 650 feet above Craigie bridge. These conditions are adapted to that point or to the placing of the dam at Craigie bridge, which we understand to be one of the possibilities. Let me say again that there is nothing in these conditions that can be omitted. There is no room left for further compromise. They must be at least as favorable to the commercial interests involved as they are here expressed. This, I think, is all that I have occasion to say, except to make any further explanation of the conditions, which are as follows: —

The property owners on the Cambridge shore between the West Boston and Craigie bridges, and upon the Broad and Lechmere canals, so called, withdraw any opposition to the proposed dam, upon these express conditions, namely: —

That any recommendation of a dam below Broad canal, and any legislative act or other provision therefor, shall include the express requirement that the permanent water level in the proposed basin shall not be below grade 8 above mean low water; and that the dam shall be provided with a free lock, substantially as designed by Mr. Blake, with a clear waterway not less than 400 feet long, exclusive of draws, 40 feet wide, and not less than 12 feet deep below mean low water; and the express requirement that the public, or the communities on which the

cost and maintenance of the dam may be charged, shall, with and as part of the work of construction, dredge a navigable channel or approach from the lock to the wharves and the canal, of sufficient width for the passage of all craft bound thither; and shall dredge the canal for the entire width thereof up to the Third Street draw, all to such depth as will afford not less than 18 feet of water to and at the wharves in the foregoing area, and not less than 14 feet of water in and above the Third Street draw to the Sixth Street draw, and not less than 12 feet of water in and above the Sixth Street draw to the railroad draw, and not less than ten feet of water above the railroad draw, at all times when the basin is at the level of grade 8 above mean low water; and shall do all strengthening and rebuilding of the walls of the canal and other structures, and removal or relocation of pipes or conduits, made necessary by such dredging; and above the railroad draw shall strengthen the present wall abutting the Page Box Factory, and construct a bulkhead, sufficient to retain filling, across the head of the canal and on the northerly side thereof from the head to the railroad draw; all such work to be done at the least possible inconvenience to the abutters, and to be complete when the dam is completed; and that the public authorities shall permanently maintain at all times such depth of water in, at and throughout the channels, canal and wharves as above specified, doing seasonably all dredging that may from time to time become necessary for that purpose, except any dredging in the canal or at the wharves the necessity for which is due to the negligence or default of the abutters; and shall permanently keep the lock, channels and canal at all times sufficiently free from ice to permit unobstructed navigation through the lock and channels and to the wharves and throughout the canal to the railroad draw; with proper provisions securing these rights to all parties in interest as contract rights, beyond impairment by the Legislature, and provisions for their enforcement by any party in interest by appropriate legal process.

If the dam is located below the Lechmere canal or channel, so called, all the foregoing conditions shall apply equally to that canal or channel, except that the depth of water therein to and including Sawyer's lumber wharf shall be 18 feet, and 14 feet from that point to the head of the canal at Bent Street.

The CHAIRMAN. The matter has been put by you very clearly indeed; I understand you wish to show that there is here a large and important commerce, whose interests cannot be neglected.

Mr. DANA. I would like to ask whether, Mr. Pillsbury, you or your clients have considered this question: If the dam should be at Craigie bridge, how much clear space ought there to be below the dam and between the railroad bridge, in order to be able to manœuvre the vessels in and out?

Mr. PILLSBURY. I am not, at this moment, prepared to answer that question. Perhaps Mr. Hunnewell, chairman of the committee of the owners, can answer it.

Mr. HUNNEWELL. As far as manœuvring is concerned, I believe about 200 feet is required to manœuvre with safety.

Mr. DANA. You think it better to have the lock right in line with the draws?

Mr. HUNNEWELL. That would obviate the necessity of having a large water space.

Mr. YOUNGMAN. I should like to say, for the proponents, that the fact that Mr. Blake put his lock on his plan on the Cambridge side was, in a way, accidental. We do not wish to insist upon that location at all. I believe Mr. Blake first drew his plans to fit the location, and with a view to making the dam less expensive by having the lock on the Cambridge side. He didn't have the time to get up an entirely new set of drawings for each of the three sites proposed.

Mr. DANA. Well, the reason that I asked that question was in connection with the changes that the Boston & Maine are making. They may relocate their bridge, and if they do, we want to have them put it down far enough for vessels to lay there if they were waiting for the proper time to get through the lock.

The CHAIRMAN. Here is some correspondence which throws some light on the matter:

BOSTON & MAINE RAILROAD, OFFICE OF CHIEF ENGINEER,
BOSTON, MASS., Aug. 21, 1902.

Mr. J. R. FREEMAN, *40 Water Street, Room 23, Boston.*

DEAR SIR: — In accordance with our conversation of a few days ago, I send you blue-print showing what we could do in the way of changing pile trestle which carries the southern division freight tracks across the Charles River. The yellow lines on print show the farthest distance we can get it away from present location, and this arrangement would give you from 330 to 350 feet of room between present line of Craigie's bridge and the edge of the trestle.

Yours truly, A. S. CHEEVER,
Assistant Chief Engineer.

BOSTON TOW BOAT COMPANY,
BOSTON, Aug. 13, 1902.

Mr. J. W. LUND, *Secretary Charles River Dam,*
40 Water Street, Boston, Mass.

DEAR SIR: — In answer to your question as to the length required for safe navigation on the Charles River between the Lowell freight pier and the lower entrance to the lock, I would say that 325 feet in the clear would be ample and proper.

Very truly yours, T. I. WINSOR,
Manager.

Mr. PILLSBURY. It is undoubtedly desirable, and may be absolutely necessary, that more room be afforded. In re-

gard to the location of the lock, in the light of our present information we think it should be in line with the draws. While I have no doubt that there are some things to be said in favor of Mr. Blake's location, the balance of convenience seems to us to be upon the other side.

Mr. DANA. There is one other point, while we are here. Perhaps Mr. Hunnewell, as being conversant with these things, can aid us. About the size of the boats or vessels that go up that canal. There is a photograph taken of that canal at low tide, and it seems almost impossible that a vessel drawing 16 feet of water could get up there. [Discussion of photograph.]

Mr. YOUNGMAN. I would like to ask, Mr. Pillsbury, if it isn't admitted by you and your clients that in case these conditions as read and laid down are complied with, you will gain certain advantages? In the first place, by getting 18 feet of water you get 2 feet more depth than you have at present.

Mr. PILLSBURY. It is admitted that we get certain advantages, but we also suffer certain disadvantages. We have come to these terms with reluctance, as I have said, because we cannot foretell exactly where we shall be under these changed conditions.

Mr. YOUNGMAN. I simply wish to get an admission of three specific advantages. The second one is, that, instead of merely having 18 feet of water at mean high tide, you are to have 18 feet of water practically all the time, except upon the possible occasions of flushing the basin. You will admit the advantage of being able to keep vessels afloat all the time they are lying at the wharves, instead of having them get aground, as they do now, and be in danger of damage by straining.

Mr. PILLSBURY. Undoubtedly. That is more of an advantage to the owners of the vessels than to us, but whatever is of advantage to them is indirectly of advantage to us.

Mr. YOUNGMAN. The third advantage I want to point out is nearly related to the second. It is that vessels can be taken up there practically any time that they arrive where the tow boats take charge of them. As I understand it, there is water enough for vessels to come up to Craigie bridge at any stage of the tide.

Mr. PILLSBURY. Presumably, whenever the tow boats could get the vessels to the lock, they could get into the basin, except in case of drawing off or flushing.

Mr. YOUNGMAN. That would be a saving in "demurrage," if that term is used in relation to shipping.

Mr. PILLSBURY. It ought to be.

Mr. DANA. I understand that it is a comparison or balance of advantages and disadvantages.*

Mr. PILLSBURY. It is, and our principal objection is the uncertainty that attends a new and untried scheme. If the conditions can be and are promptly and properly fulfilled, we ought to be substantially as well off as we now are. Whether we shall be, or can be, is uncertain, and it is this uncertainty that disturbs us.

Mr. DANA. Has any estimate been made, or have you had any experience, regarding breaking up ice, as to what it would cost to make channels, etc.?

Mr. PILLSBURY. We talked with the tow boat men, and such information as we have is from them. I believe that we tried to get a direct estimate from them, and found that we could not. No direct estimate has been made, I believe. I suppose it is undoubtedly true that the freezing of the basin to such an extent as to actually obstruct navigation has been infrequent in the past; but still water and fresh water will of course freeze more quickly, and deeper.

Mr. HUNNEWELL. Formerly it was possible for the canal to freeze up, but in later years it has not frozen to any extent. Of course there is a source of apprehension in that direction, in the substitution of fresh water for salt, which is a very vital change in conditions affecting the formation of ice.

Mr. DANA. Mr. Hunnewell, have you had experience as to about how thick the ice forms, and about how thick ice you could cut through?

Mr. HUNNEWELL. With salt water I have seen them cut through 8 inches; with fresh water the boatmen tell me it is almost impossible to cut through 4 inches.

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* In this connection the committee received the following statement from the Boston Tow Boat Company: —

BOSTON TOW BOAT COMPANY, BOSTON, Nov. 24, 1902.

HENRY S. PRITCHETT, Esq., *Chairman Committee on Charles River Dam, 40 Water Street, Boston, Mass.*

DEAR SIR: — I have been asked to give an opinion as to the effect of the construction of a dam in Charles River in the vicinity of Craigie bridge. I have been asked particularly to state whether a lock would constitute a hinderance to navigation that would not be offset by the advantage to shipping, and especially to the tow boat companies, in being able to reach their terminal points at any stage of the tide.

It is my opinion that the advantage of being able to go to the wharves above Craigie bridge at any hour of the day or night, without having to wait for high tide in the basin, would far outweigh the slight loss of time in taking a tow through a lock. At present we can go through the draw at Craigie bridge at low tide, but there we have to wait for high tide to put a vessel alongside of any wharf above that point. To keep the basin constantly at a level equivalent to that of mean high tide would be an improvement over present conditions which would be financially advantageous to the owners of both vessels and cargoes. Several hours' time could often be saved both in the delivery and in the unloading of vessels.

Yours very truly, T. I. WINSOR, *Manager.*

Mr. DANA. I have seen boats in Duluth cut through very much thicker ice than that.

The CHAIRMAN. I understand Mr. Pillsbury to say that this statement comprises certain conditions which those who favor the dam consider reasonable on your part.

Mr. PILLSBURY. The counsel have agreed with us that these are reasonable conditions; and they stipulate with us, so far as they can, that the terms here formulated shall be incorporated into any recommendation of or legislative provision for a dam at any point below the entrance of Broad canal. Unless they are adopted, the property owners must oppose the building of the dam.

TABULATED STATEMENT, SUBMITTED BY MR. PILLSBURY.

Broad Canal.

Number of separate estates,	33
Number of separate owners,	32
Number of occupants not owners,	23
Number of coal dealers,	2
Number receiving coal, not dealers,	4
Number of lumber dealers or receivers of lumber,	4
Number of all others,	23
Area (feet),	1,552,959
Valuation of land,	$756,900
Valuation of buildings,	632,400
Total valuation,	$1,389,300
Amount of coal received annually, 190,000 tons,	$843,500
Amount of lumber received annually, 33,000,000 feet,	523,000
Amount of oil received annually, 200,000 barrels,	275,000
Amount of stone and marble received annually, 10,000 tons,	20,000
Amount of other material received annually,	73,500
Total,	$1,735,000

Lechmere Canal.

Number of separate estates,	13
Number of separate owners,	13
Number of occupants not owners,	6
Number of coal dealers,	2
Number receiving coal, not dealers,	2
Number of lumber dealers or receivers of lumber,	2
Number of all others,	7
Area (feet),	948,306
Valuation of land,	$390,700
Valuation of buildings and improvements,	64,000
Total valuation,	$454,700
Amount of coal received annually, 74,000 tons,	$370,000
Amount of lumber received annually, 5,500,000 feet,	139,000
Amount of stone and marble received annually, 68,000 tons,	78,500
Amount of piles received annually, 50,000,	125,000
Amount of other material received annually,	14,000
Total,	$726,500

Summary. — Broad and Lechmere Canals.

Number of separate estates,	46
Number of separate owners,	45
Number of occupants not owners,	29
Number of coal dealers,	4
Number receiving coal, not dealers,	6
Number of lumber dealers or receivers of lumber,	6
Number of all others,	30
Area (feet),	2,501,265
Valuation of land,	$1,257,600
Valuation of improvements,	696,400
Total valuation,	$1,844,000
Amount of coal received annually, 264,000 tons,	$1,213,500
Amount of lumber received annually, 38,500,000 feet,	662,000
Amount of oil received annually, 200,000 barrels,	275,000
Amount of stone and marble received annually, 78,000 tons,	98,500
Amount of piles received annually, 50,000,	125,000
Amount of other material received annually,	87,500
Total,	$2,461,500

Abutters on the Cambridge Shore, between Craigie and West Boston Bridges and Broad and Lechmere Canals.

Owners.	Area (Feet).	Assessed Value of Improvement.	Material.	Assessed Value of Land.	Assessed Value of Material handled.
Barber Asphalt Paving Company and others,	-	-	Sand and asphalt,	-	$11,000
Austin & J. B. Ford,	20,050	-	Stone, 9,000 tons,	$10,000	18,000
Fred Ayer,	161,511	-	-	48,500	-
Cambridge Gas Light Company,	130,857	$80,000	Oil, 50,000 barrels; castings, 1,000 tons; coal, 30,000 tons,	112,700	275,000
Seavey & Co.,	87,120	15,000	-	45,800	-
Mowry & Phillips,	35,112	1,200	-	13,200	-
Geo. H. Bird and others,	12,000	2,500	-	14,500	-
Standard Oil Company,	45,745	20,000	Oil, 12,000 tons,	35,000	200,000
American Rubber Company,	184,944	146,000	Coal, 4,000 tons,	179,100	14,000
Boston Woven Hose,	138,300	165,800	-	235,000	-
Geo. G. Page Box Company,	76,300	7,100	Lumber, 8,000,000 feet,	80,500	128,000
Sylvester Tower,	-	30,900	-	48,900	-
Heirs of L. Greely,	46,868	26,100	-	49,500	-
A. A. Elston,	18,998	-	-	10,300	-
Laura D. Cogswell,	6,877	-	-	4,500	-
Annie B. Matthew,	9,757	-	-	5,300	-
W. H. Miller,	19,499	10,800	-	22,800	-
Josiah Burrage estate,	4,850	3,000	-	6,000	-
W. H Wood & Co.,	95,150	3,400	Lumber, 25,000,000 feet,	67,200	395,000
E L. Hunnewell,	1,750	2,500	-	3,500	-
Estate of Geo. Fisher,	16,800	5,000	-	20,000	-
Estate of G. B. Rogers,	18,500	8,500	-	21,500	-
Sargent & Mason,	21,576	-	-	14,000	-
Bay State Fuel Company,	-	11,100	Coal, 90,000 tons; wood, 1,500 cords,	-	435,000
Estate of E. H. Luke,	19,200	10,000	-	22,600	-
Cambridge Electric Light Company,	27,553	3,800	Coal, 7,000 tons,	22,700	24,500
Heirs of W Dalrymple,	12,839	-	-	8,700	-
Heirs of Howard Coon,	8,400	5,600	-	11,500	-
J. J. Horgan,	17,385	3,000	Stone, 1,000 tons,	16,000	2,000
C. A. Morse,	22,650	1,500	-	17,000	-
Rawson & Morrison,	19,650	17,000	-	32,700	-

Heirs of Benj. G. Smith,	41,964	1,900	–	33,200	–
Caroline A. Smith and Benj. C. Clark, trustees,	26,707	–	–	18,000	–
S. & R. J. Lombard,	–	–	Stone, 35,000 tons,	–	70,000
J. Frank Wellington,	63,000	–	–	30,100	–
Wellington & Wild,	–	12,800	Coal, 55,000 tons; wood, 1,000 cords,	–	252,500
C. Linnehan,	46,045	17,500	–	49,300	–
Herbert L. Sanborn,	45,730	1,300	–	33,200	–
Everett W. Brooks, trustee,	34,040	4,000	–	26,400	–
D. Proudfoot & Co.,	–	–	Coal, 18,000 tons; wood, 500 cords,	–	86,000
E. D. Sawyer & Co.,	27,600	–	–	–	–
	16,330	1,500	Lumber, 4,000,000 feet,	40,800	64,000
G. Gorham Peters,	46,000	3,500	–	22,200	–
Parker & Page,	–	–	Lumber, 1,500,000 feet,	–	75,000
Ricker & Co., part lessees of Smith & Clark wharf,	–	–	Stone, 30,000 tons,	–	60,000
J. Harrington,	29,300	4,000	Stone, 5,000 tons,	14,200	10,000
Chas. E. Hall & Co.,	42,000	17,600	Coal, 1,000 tons; marble, 2,000 tons; sand, 1,500 tons,	34,400	25,500
J. T. Scully,	413,500	–	Piles, 50,000,	58,600	125,000
Catherine Doherty,	56,000	–	–	22,400	–
Henry M. Whitney,	80,000	–	–	32,000	–
J. W. & W. G. Coleman,	79,977	34,000	Coal, 49,612 tons; wood, 380 cords,	79,800	277,500
G. L. Damon,	101,330	22,000	–	63,900	–
	2,445,642	$718,500		$962,300	$2,547,000

BRIEF OF JAMES R. DUNBAR AND WILLIAM D. TURNER.

Submitted on behalf of Charles Head, Lewis S. Dabney and Howard Stockton, a committee representing residents and property owners on Beacon Street and the borders of the Charles River, opposed to the construction of the dam.

I.

The question to be decided by you, namely, whether the construction of a dam across Charles River at the place proposed is feasible and desirable, is one of such far-reaching importance, involves such probable expenditure of money and is likely to affect so intimately the comfort and health of the communities upon the river, as to require the most careful study, the best attainable trained scientific aid and the most accurate knowledge of conditions and probable results.

It is of such importance that no action looking to radical changes in present conditions should be recommended, unless and until it can be predicted with certainty that injurious results will not follow such changes; nor, indeed, if ordinary prudence be the guide, until substantial and sufficient advantages to warrant the necessary large expenditures are assured.

It has already appeared that, upon the most important matters upon which you will be called upon to pass, in reaching a conclusion upon the main issue, there is a wide difference of opinion among the learned and experienced engineers who have given opinions and estimates. This, we assume, is not so much due to the natural tendency of men to present that which is in favor of the person or side who asks for the opinion, as to the inherent difficulties of the subject, involving, as it does, conclusions upon many matters not thoroughly understood, and in fields in which sufficient data have not yet been gleaned to warrant positive and reliable conclusions.

II. — Desirability not shown.

The petitioners claim that the dam is desirable, for the following reasons: —

First. — Because the people need a park as a place of rest and recreation, which shall be within easy access of the crowded tenements of the North End.

Second. — Because to maintain a constant water level at about 8 feet above mean low tide will in itself be an adornment to the cities of Boston and Cambridge, and will enable the Park Commissioners to lay out parks around the basin, of which the shores will be treated in a more pleasing and artistic manner than would be possible with the fluctuating tides, as at present.

Third. — It is suggested, but not much dwelt upon, that for rowing, not such as the poor people may be expected to indulge in, but for expert oarsmen, such as the crews of Harvard College, the river would be improved by a dam. One of the last witnesses called by the petitioners, outside of the engineering experts, referring to himself as an old oarsman, still very fond of rowing, said that he found his efforts in this sport greatly restricted at low tide.

The witnesses who were called to testify to the desirability of the proposed dam confined themselves to generalities. They argued that parks, and especially water parks, are good things; that the health and comfort of the people are promoted by them, and that thus they are made better citizens. It was said that the rooms of the committee could easily be filled five times over with persons who would testify on these general lines. But this line of argument may be conceded without touching the question whether this dam is desirable. That depends upon other considerations.

Admitting that parks are good things, if it is proposed to increase the number, and to establish one around the lower Charles, as has already been done in part, it may be done without the construction of a dam. It would seem as if the land parks already established were sufficient for the present, and for a long time to come. A great many millions of dollars have been spent, most of which is borrowed for future generations to pay, for this purpose. Witnesses who appeared before the committee have referred with pride to the fact that Boston's parks and public baths are the best in the world. But it is said we have not enough water parks; that it is not alone the scenic effect which is important, but it is necessary that the people should have water in which they may bathe, and on which they may sail and paddle about in sum-

mer and skate in winter. It is said that there will be a beautiful basin of water without a current, where tens of thousands of children, boys and girls, as well as older people, men and women, can pass their afternoons and their evenings in the summer; that this will be the place where the people can go and skate as much as they like, and where in summer the youngsters can tumble off into the water and be pulled out.

But these pictures of the imagination, however pleasing to contemplate, are not likely to be realized, even if a dam should be constructed.

The lower basin of the Charles is exposed to the southwest winds, which prevail in summer. Persons who are not expert in the management of boats usually know enough not to venture out upon water as deep and wide as this basin. They know that if a breeze springs up, as it frequently does very suddenly, they are going to get into trouble. If they have the necessary twenty-five or fifty cents an hour to spend on boats, they are not going to amuse themselves by taking their children out where they can drop into from twenty to thirty feet of water. It was confidently predicted, as Professor Porter has pointed out, and with much more likelihood of the predictions being realized, that, when the Muddy River Park was established in connection with the park around Jamaica Pond, boating on these waters would become popular; but these prophecies did not come true. It is not the current which makes the water dangerous, but its depth and the exposure to the winds.

There is at City Point a Marine Park, with a fully equipped boat service. The waters there are frequently as smooth as those of the lower Charles, and are equally liable to become rough. The current is not formidable. But of the great crowds who seek this park for rest and recreation, a very small percentage, and these not of the "pater familias" type, ever patronize the row boats or the sail boats, both because they are too expensive, and because they do not know how to sail or row, and have not the leisure and opportunities which are necessary to learn these accomplishments. Of the inexperienced persons who do venture out, a large number are rescued from drowning annually by the life-saving station established there.

So as to skating in winter. Any one who is fond of this sport knows how seldom so large a sheet of water as this basin can be found in a condition safe or suitable for skating in the vicinity of Boston. The Muddy River, which ought to freeze much oftener and with less roughness than this pro-

posed basin, on account of its smaller size and sluggish current, is hardly ever in fit condition for skating.

Bathing, on the other hand, is possible in the Charles, although not as pleasant as at the great beaches which have been fitted with public baths unequalled in this country. It must be admitted that to change the water from salt to fresh would materially diminish the use of the Charles for bathing purposes, and deprive the bathing of much of the invigoration and enjoyment which cool salt water alone can give.

Professor Porter, who is himself an oarsman, and has for many years been familiar with the lower basin of the Charles River, recognizes the fact that it is not a suitable place for boating for inexperienced persons, for the reasons above stated; and he has good grounds for his opinion that the results of a dam in this respect, as well as regards skating in winter, would disappoint the expectations of those who see the basin in their minds' eye bearing in boats or upon the ice a gay multitude of pleasure-seeking people.

It is claimed that a park at this point is necessary as a breathing place for the crowded districts of the North End, because the other parks are too remote. Mr. Storrow says that for this purpose a walk of half an hour is too much, and that fifteen minutes on the cars is too far away. It is true that, besides our park reservations, open squares and breathing places are desirable; but these must be located in the very midst of the crowded districts. They must be not even twenty minutes' walk away, but just within reach, where the small children can be safe, and almost in sight from their homes. If a park is to be established around the lower basin of the Charles River, it must not be confused with this kind of a park. It would not answer the same purpose. It must be considered as a reservation, of the same class as the Common, Public Garden, Back Bay Fens, Marine Park, Charlesbank, and the other parks with which the city is already so bountifully and even lavishly supplied.

But admitting, for the sake of argument, that a park at this point is required, we approach the question whether the dam is desirable, and whether the scenic effect to be gained by a high and constant level of water is to be preferred. It is not insisted that the absolute level of the water is of so much importance, but it is claimed that the low tide exposes foul-smelling flats, and that the walls at the banks of the river as at present constructed are unsightly.

But a dam is not necessary to remedy these conditions. The flats have been largely removed by dredging, and may be completely so removed. The river banks may be treated

with sloping shores, as well as with upright retaining walls. The shores would have to be protected as much with the dam proposed as without, because the moment it is conceded that it may be necessary to lower the water at times, permanent provision must be made to protect the banks from sliding.

The question as to the most artistic disposition of the grounds and shores about the basin, if a park is to be established there, is quite independent of the construction of a dam, and need not be considered in connection with the latter proposition.

III. — Stagnant Fresh *v.* Flowing Salt Water.

The essential change which the construction of a dam across the Charles River would effect is this: instead of a body of salt water, changed and renewed from the ocean twice in each twenty-four hours, we should have a practically stagnant body of fresh water. If it is said that the water will not be stagnant, but that provisions will be made for changing it frequently, we should be informed how frequently it is proposed to change it, and by what laws will such changes as are proposed be secured and made certain? Will the times of change be entrusted to the discretion of some board or official, who may be of opinion that no change is necessary? Or will the times of change be stated in the same statute under which the means of obstructing the flow of the stream are obtained? If it is conceded that a change twice a day, or once a day, or once in every few days, is necessary or desirable, obviously the dam accomplishes nothing.

Therefore, the first question resolves itself into this: assuming that a constant water plane at an elevation of grade 8 is to be preferred to a shifting water plane with its variety of ebb and flow, and that for this supposed æsthetic advantage it is worth while to spend the number of hundreds of thousands of dollars which the structure of the dam alone will cost, and the millions of dollars of expenditure necessary to insure pure water in the basin, and ignoring for the moment all injury to navigation, the harbor or other interests, how often will it be necessary to renew that body of water, to prevent a nuisance and to preserve the health of the community from threatened danger? At present, although with the change of the entire contents of the basin twice a day there is no actual offence, the water is none too clean.

The question suggests itself, Why enter into so difficult an inquiry upon an assumption which seems to have so slight a foundation to support it? It is merely a question of taste, whether the fixed water plane is more agreeable to the eye than a varying one. What advantage has grade 8 over other grades? If the object is merely to cover the flats with water at low tide, that object may be accomplished by continuing the process of dredging, which has already been carried so far that only a comparatively small and insignificant area of flats now remains exposed at low tide. The Joint Board, which recommended a dam in 1894, declared in its report that, even if a dam be constructed, it will be none the less essential to remove the flats by dredging.

Professor Porter states that over 3,000,000 cubic yards of material have been dredged from the river within the past eight years, and used as filling for the Esplanade, Cambridge parkway, etc., which is equivalent to an increase of two and one-half feet in depth of water over the whole proposed basin; that only a few acres of shoals, barely visible at mean low tide, remain on the Boston side above Harvard bridge, and some narrow strips here and there at the foot of the sea walls.

If, however, the treatment of the banks or other æsthetic considerations, or any of the arguments advanced in the premises, seem to make it desirable that a level be established above mean low water, below which level the surface of the water of the basin shall not be permanently lowered, and that a dam, if feasible, is therefore desirable, there is surely no magic in grade 8 for such level. It is not perceived that grade 8 possesses in these respects, or in any respect, any advantage over grade 5. A half-tide dam at grade 5, such as the Richmond dam in the Thames, which would still permit the free inflow, twice in each twenty-four hours, of the fresh sea tide water above grade 5, would afford all the benefits claimed for a dam at grade 8, and would at the same time preserve the basin as a salt-water basin, which would to a much less extent than a stagnant fresh-water pond at grade 8 be attended with the dangers and objections arising from sewage pollution, from destruction of fish and vegetable life, from increase of temperature, from disturbance of the level of ground water in adjacent territory, and from many other sources. The expense, too, involved in the establishment of a half dam at grade 5 would be very much less, because it would not make it so absolutely indispensable to guard the basin from all pollution, and for

other reasons, which will readily be perceived by the committee.

If it is said that the current must be checked, what advantage is there in that? As we have pointed out above, the danger to inexperienced boating parties is not due to the current, but to the depth and extent of the basin and its exposure to the winds.

If this dam is really asked for, not for the poor inhabitants of the crowded districts of the North End, but for the rowing interests of Harvard College, it can be easily understood why the dam is desirable, — it would certainly improve the river for the use of college crews. But the health of a community cannot be jeopardized in order to provide a course for racing in shells; and therefore it is the duty of those upon whom the responsibility of a decision rests to make absolutely sure that no danger will result to health before they can be justified in recommending an experiment such as the one proposed, and involving consequences of such magnitude, no matter what the supposed æsthetic advantages may be.

Investigation of other phases of this subject is useless, unless this question is established beyond the possibility of a doubt. Experiment upon this delicate and important question cannot be justified.

IV. — Sewage.

The construction of a dam will create conditions practically the same as those of a mill pond. The quantity of sewage entering this pond cannot be accurately measured. The overflows connecting with the metropolitan and Boston main drainage systems, of which there are a large number discharging directly into the river, are at different levels and in operation irregularly, and no record is kept of the times during which those on the Boston side are discharging.

It is estimated by Mr. Brown, the engineer of the Metropolitan Water and Sewerage Board, in charge of the sewerage works, that the average amount is now not more than seven per cent. of the whole; and that when the new, high-level sewer, now in process of construction, has been completed, the amount now entering the basin will be materially reduced; but office computations on a matter of this sort are not and cannot be very certain or reliable. And, as Mr. Hering observes, it is not the averages, but the worst conditions, which must be considered.

The only actual and systematic observation of the amount

and frequency of the discharge into the Charles River which seems to have been made is that of Dr. Barnes. He states that he has observed sewage flowing into the river for five or six days after a storm; and, as he lives at Hereford Street, opposite one of the overflows, he has had an excellent opportunity to observe the frequency of the overflow. Very often, he states, he has seen the sewage, after a comparatively slight rainfall, extending half way across the basin, with the line of demarcation of the inflow clearly visible; and he has observed that very much more sewage appears to come in from the Boston side than from the Cambridge side. Dr. Barnes states from his notes his actual observations of the large quantities of offensive sewage which he has seen flowing into the river after comparatively slight rainfalls; and the astonishment of Dr. Prince in having his attention called to these facts is an indication of how little even those living close by the overflows are aware of the amount of sewage which actually enters this basin.

It is Dr. Barnes' opinion that, if the waters in the basin are not frequently changed, there will be offence from decomposing sewage; that during the hot weather and summer months it would be necessary to empty the basin about once a day. Dr. Barnes emphasizes the distinction between sewage discharged into running streams, where the constant motion prevents offence, and a discharge into a stagnant body of water, where, he says, even a small amount of sewage is capable of decomposition and liable to smell. He refers to the offensive conditions aleady existing in the Fens basin, and states that he has seen on several occasions the evidence that the oxygen in the water had been completely exhausted, and thousands of dead fish upon the shores.

Professor Porter is also of opinion that the amount of sewage entering the basin would create offence; and he refers to the difficulty of estimating the actual increase in the amount of sewage to be provided for by sewerage works, and to the fact that the estimates of engineers in regard to the Boston main drainage works and the metropolitan systems in the past have usually been too small. He estimates the quantity of sewage going in from the Boston side as equivalent to the constant discharge from a population of 21,000 persons, and this upon the assumption that the amount of the overflow is only seven per cent., in accordance with the observations on the Cambridge side, although the testimony of Dr. Barnes indicates that it is very much greater. He also states that there is little authentic information as to the frequency or extent of sewage overflow into

the river. Professor Porter also draws attention to the fact that the separation of the house sewage from the street wash, which is being introduced in new work from time to time, will not by any means relieve the situation. The street wash is as capable of producing offence as the house sewage.

Mr. Rudolph Hering is of opinion that the pollution of the basin by the overflow of sewage would give unpleasant, stale and annoying odors, which he thinks would be possibly dangerous to health, and certainly uncomfortable and offensive, and which he thinks should not be tolerated in a public park.

It is unnecessary to repeat the grounds upon which these experts have based their judgments, as these grounds are fully stated in their testimony or written reports. These experts were employed to advise, and not retained in a controversial capacity, for the purpose of carrying a point.

If there will be in fact no injury from the proposed basin, Mr. Dabney's committee have no reason to object to the construction of the dam; but when they are advised by the most competent and well-informed authorities to whom they can apply for advice and information that there is danger of offence not only to their comfort but even to their health, if they continue to live in the houses which they own or occupy along the borders of the proposed basin, they have good grounds for protesting against the trial of an experiment of which the consequences may be so disastrous, and for which so little real exigency exists.

The single question of sewage is alone a sufficient objection to the proposed dam. The fact that certain private drains enter the basin from the Beacon Street houses is unimportant. These drains may easily be diverted whenever the city sees fit to construct a sewer for that purpose; and the quantity of sewage discharging through these private drains is infinitesimal, as compared with the immense amounts discharged through the overflow from the main drainage and metropolitan systems at Hereford Street, Charlesgate East, Saint Mary's Street and many other points. But the fact that this private drainage exists — and it exists only because the city has not seen fit to make other provision for it — is laid hold of by the petitioners for the dam for the purpose of making it appear that the opposition is based upon insignificant and purely selfish grounds, whereas, in fact, the real objections are upon grounds which, although affecting principally the immediate residents along the banks of the Charles River, are also common to the entire community.

The water in the basin will be much warmer if the proposed change is carried out, and will not cool the air as much in hot weather.

The waters in the Muddy River Park and Back Bay Fens, although renewed constantly from the river, are foul and disagreeable. Green scum forms on them, and stale odors are perceptible at times, which, though not necessarily injurious, are unpleasant. There is constant effort to improve these conditions, and only recently the mayor has asked for money to divert Stony Brook; but unless *all* sewage and street wash is excluded from the proposed basin, the constant accumulation of offensive matter, which can never be as thoroughly cleaned out, if a dam is constructed, as by the free action of the tides, is likely to give constant trouble and discomfort, at the very least.

V. — Malaria.

It is well known that during past years malaria has appeared upon the banks of the Charles River, and has been gradually extending down the river towards the Watertown dam. This malaria has been supposed to be due to the collection of stagnant water and disturbance of the level of the ground water in the vicinity of the river. It is now said that modern science has discovered that malaria can only be transmitted through certain kinds of mosquitoes, principally the *Anopheles* variety; but inasmuch as the same conditions to which the presence of malaria has been usually attributed are admitted to be favorable to the propagation of the *Anopheles* mosquito, it seems to be immaterial, for practical considerations, whether the original germ of the disease comes directly from the ground to the human being, or is transmitted by the mosquito, who has obtained it from plants or other sources unknown. The fact remains that, where the ground water has been raised or stagnant water is allowed to exist, malaria is to be found.

It is the opinion of competent engineers that the effect of the dam will be to raise the ground water; others say that it will not be raised; and still others that it will be lowered. There will be certainly many little pools and quiet places where mosquitoes may thrive.

Our position is, that, as there is no malaria now below the Watertown dam, it is a safe policy not to create conditions which may invite it, and that to do otherwise is not safe.

VI. — The Alster Basin.

The Alster basin in Hamburg is prominently referred to in support of the petitioners' case, regardless of the fact that there not only house sewage but street wash has always been rigidly excluded. That city had no existing sewerage system to be remodelled and reconstructed when the basin was established. It was many miles from the salt water, and no change from salt to fresh water was involved. They did not have to balance the comparative advantages of salt and fresh water there, because they did not have the salt water and could not get it.

We do not contend that it would be impossible to construct a fresh water basin around the lower Charles which would be free at least from offensive conditions, if not as desirable as the salt water from the ocean; but, in order to do so under the existing conditions, much more is required than the advocates of the dam propose to do. Mr. Hering sums up these requirements as follows: —

> In order to secure the æsthetic advantages of the proposed park, without introducing new conditions that would be objectionable in one way or another, it is necessary, besides building the dam, with its locks, gates and machinery for operating the same, to build also drains to keep out of the basin all the overflow sewage, the first rainwater wash from frequented streets, and the refuse from manufacturing establishments on the Charles River above the metropolis. It is also necessary to provide shore protection around the proposed basin, to dredge out some of the flats, and to provide machinery for establishing a better circulation in the Fens basin. Besides this construction work, it will be necessary occasionally to dredge silt and refuse deposits from the basin, and also from the river below the dam, and the harbor.
>
> The effects of the dam are therefore wide-spreading, embodying numerous risks, which require the most careful operation and management of the works, and also large expenditures of money.
>
> The entire cost of constructing and maintaining the proposed works should be carefully ascertained along the lines above discussed. Only then will it appear whether or not the price to be paid for a park that is wholly above suspicion is justified by the advantages to be gained over and above those that would be lost by abandoning the present tidal flow.

VII. — Expense and Other Objections.

It is not our purpose to enter into any detailed investigation of the question of the expense which will be incurred by the construction of a dam. Assuming that the cost of the construction of the dam and its auxiliary works can be approximately estimated it is still apparent that the indirect

expenditures rendered necessary will vastly exceed this cost, and will be out of all proportion to the value of all possible or supposed benefits to be derived. If we are to have a fresh-water basin of pure water, free, as it should be, from all sewage and street washings, not only from the cities of Boston and Cambridge but from the remainder of the tributary water-shed, the expense will amount to millions.

A lake of fresh but impure water in a park is a nuisance, not a benefit, and a constant source of annoyance and expense, of which the amount cannot be estimated even approximately. Our experience in regard to Stony Brook and the Back Bay Fens is a sufficient illustration of this.

It is not proposed to attempt to discuss in this brief the numerous other objections to a dam, which are covered by the carefully considered opinions of the experts who have advised us, and which are in the hands of the committee, — such as the question of whether sufficient provision can be made to guard against floods in time of freshets, and what it should be if a dam is to be built; whether or not the ground water will be raised or lowered ; what the effect will be upon the animal and vegetable life in the basin of a change from salt to fresh, and possibly from fresh to salt water, at uncertain intervals.

The question of the probable shoaling which the dam may occasion in Boston harbor, — a question of very great importance, — is one with which we do not undertake to deal. The persons who live on the north side of Beacon Street are not more affected by injury to the harbor than the other inhabitants of Boston, and it would be perhaps presumptuous on their part to assume the defence of this part of the petitioners' case ; but their position with reference to all these matters is the same, — that no experiment should be tried. If the issue is not certain, — and an issue is not certain when eminent authorities disagree, — there is too much at stake to justify us in meddling with the natural conditions now existing.

The Board of Harbor and Land Commissioners, after most exhaustive inquiry, have recorded their opinion that this is a matter of which the result cannot be foretold with certainty ; and that was to their minds a sufficient reason for declining to assume such an unnecessary risk.

Although the project of a dam has been brought forward from time to time during the past forty years, it has always failed to receive sufficient approval to cause it to be adopted,

for reasons which are as applicable to-day as ever, namely: because the real advantages to be gained are so slight; because the expense of trying the experiment is so great; because the certain injury to many business interests established on the river is considerable; and because the risk of far greater injury to other and more important interests is such that to incur it is unwise.

JAMES R. DUNBAR,
WM. D. TURNER,
Of Counsel.

CLOSING ARGUMENT FOR THE PETITIONERS.

SUMMARY.

References and Abbreviations.

Record, — the printed record of the testimony given at the public hearings in this case.

Joint Board, — report of the State Board of Health and the Metropolitan Park Commission, sitting jointly, upon the Improvement of Charles River, House Doc. No. 775, of 1894.

H. & L., — report of the Board of Harbor and Land Commissioners to the Legislature of 1894, on the Charles River Dam.

City Doc., — annual department reports and other documents printed by the city of Boston.

Mattice, — report to the city of Cambridge in annual report of Cambridge Park Commissioners for 1894.

Mr. Chairman and gentlemen: —

The scope of this inquiry is twofold: the committee is directed to investigate and report "upon the feasibility and desirability of constructing and maintaining a dam across the Charles River between the cities of Boston and Cambridge, in the vicinity of the bridges known as Craigie bridge and West Boston bridge."

By "feasibility" we suppose was meant the practicability of the structure with reference to construction, cost, etc.; and by "desirability" we understand to have been intended

the broader question, whether the dam, if practicable from a physical and financial stand-point, would be a desirable or useful thing for the community from the stand-point of commerce, health and recreation.

At the public hearings given by the committee both sides have been represented; expert opinions and arguments in criticism of the project have been presented by the same parties who opposed a somewhat similar proposition before the Harbor and Land Commission in 1894; the petitioners or advocates of the present plan have caused the various sanitary, scientific and commercial questions involved to be investigated by competent engineers, and have submitted the results to the committee; and the committee, not being hampered by lack of funds, has examined these questions for itself, with the assistance of other competent experts retained solely in the public interest.

It is obvious that the conclusions of this committee, whether favorable or unfavorable to the damming of the river, will be likely to be accepted by the public as conclusive.

In a case conducted as this has been, before a tribunal which, as authorized by the Legislature, will take into account not only the facts, opinions and arguments submitted at the hearings, but such other information as its own investigations (made after the evidence for the petitioners and remonstrants had been heard) may disclose, as well as the results of prior investigations by other commissions, the function of counsel is far different from that appropriate in the presentation of an ordinary case, either in the law courts or before a legislative committee. No attempt will therefore be made in this brief or argument to discuss the evidence with the detail that might be fitting upon another occasion, or even to marshal the facts relied on by the petitioners. Our purpose will rather be to point out the overwhelming desire of the community for such a water park as can only be secured by the construction of a dam across the river at its mouth, to briefly summarize the argument that such a dam is feasible and unobjectionable from any stand-point, and to suggest the lines of inquiry which we think will be most useful to the committee in reaching a just and satisfactory conclusion. The main departure from this course which we shall permit ourselves will be with reference to the question of tidal scour. As to this fundamental question, we think that practically all the facts that can be of assistance in determining the question are now before the committee; that these facts are

so few in number and so plain in meaning that ordinary intelligence only, not scientific training, is necessary to correctly interpret them; and that, whether considered by the professional engineer or the intelligent layman, they admit of but one interpretation and conclusion. We shall therefore discuss this branch of the case with some detail.

I.—The History of the Project.

Ashamed of the filthy and unsanitary condition of the lower reaches of the Charles River, and inspired by the example of Hamburg and other cities having similar and even smaller opportunities, the inhabitants of the communities bordering on this river have long desired the conversion of the tidal portion of it into a water park, and the maintenance therein of a more or less constant water level by means of a dam erected across the river at its mouth.

As early as 1859 the Legislature was petitioned by George H. Snelling and others to authorize the construction of a tidal basin in the Back Bay, the petitioners stating that they had been "assured by the most experienced engineers that it was perfectly practicable to keep such a basin at any desirable level and to insure a constant renewal of the water at every tide." The basin proposed at this time was to be about 700 feet in width. See memorial to the Legislature, of April 5, 1859. In 1860 the matter was taken up by Josiah Quincy, mayor of Boston in 1846–48. His petition was referred to the next General Court, on the assembling of which Governor Andrew in his inaugural address of Jan. 5, 1861, urged the adoption of measures "to secure to the public health the benefits contemplated by the reservation of a full basin, agreeably to a memorial of Hon. Josiah Quincy and other citizens to the last Legislature." See also the letters of Governor Andrew, Josiah Quincy, Chas. Sumner and others, written to Mr. Snelling in 1859 and 1860, reprinted in City Doc. 128 of 1869.

Nothing came of these efforts; and in 1869 it was seriously proposed to fill not only the Back Bay, but the whole river basin, except a narrow channel for the stream. See testimony and arguments in City Doc. 128 of 1869. The project was defeated.

Ten years after the Snelling memorial the agitation for a public park system in Boston took definite shape, and in a letter to the "Boston Daily Advertiser" of Dec. 4, 1869, the late U. H. Crocker advocated the making of a park out of that portion of the river between the West Boston and

Brookline bridges by the construction of a dam "two or three feet above low-water mark." An act was passed the following year (St. 1870, c. 283), providing for the establishment of a Metropolitan Park Commission, subject to acceptance by the people of Boston by a two-thirds vote. In a pamphlet evidently written by Mr. Crocker and published by Rand, Avery & Frye, between the passage of this act and the vote upon it, the plan of a water park was gone into with greater detail, and a map was annexed, showing a large salt-water basin between the West Boston and Brookline bridges. The dam is not shown on the plan, but it appears from the context that, as outlined by Mr. Crocker in his letter to the "Advertiser," it was contemplated to keep the flats always covered by means of what would practically have been a half-tide dam. At the election in November the act received a majority of the votes cast, but not two-thirds,* and was therefore rejected. In the popular discussion of the project previous to the election the principal argument brought against the act was that it contemplated a State rather than a Boston commission.

The Boston park system was finally established under St. 1875, c. 185, which provided for a city, not a State, commission. A special election was held on June 9, 1875, the act was accepted by a substantial majority,† and commissioners were forthwith appointed by the mayor.

The first work of this commission was to prepare a general plan or scheme for a system of public parks, which was outlined in the elaborate and well-known "Second report of the Boston Park Commission," dated April 24, 1876 (City Doc. 42 of 1876). An essential part of the scheme of public parks recommended by the commissioners in this report, which referred to the Alster basin in Hamburg and similar improvements in other cities, was the construction of a river park and an embankment from Leverett Street to Cottage Farm. See pp. 4, 15–18.

Work upon the Boston park system was begun in 1877 by the acquisition of lands for a park in the Back Bay, since called the Fens. The construction of this park was begun in 1879 and finished about the year 1894.

The construction of the embankment included in the general scheme of 1876 was begun under the authority of St. 1881, c. 92, authorizing the filling in of the river between Craigie and West Boston bridges. This act was accepted by the city council Nov. 28, 1882, land was acquired in 1883, and the work was done between 1883 and 1889. By St. 1881, c. 197, a plank walk was authorized behind the

* As required by this act. † The Act of 1875 required a majority vote only.

houses on the water side of Beacon Street between Berkeley and Hereford streets, but was never constructed. By St. 1891, c. 344, a solid filling was authorized between the West Boston bridge and the rear of the Beacon Street houses; and by St. 1893, c. 435, the city was empowered to extend this embankment to the Fens. Plans have been prepared for this embankment, and the commissioners have repeatedly urged its construction; but the work still awaits an adequate appropriation by the city council.

The twelfth annual report of the Board of Park Commissioners for the year 1886 (City Doc. 24 of 1887) contains, on p. 18, this statement: "Since the earliest report of the Board it has always been its opinion that the improvement in the Charles River basin is a matter of such importance to the future city of Boston that no effort should be spared to secure its final consummation. . . . The city should urge upon the Legislature the importance of devoting the shores of the basin to ornamental purposes, in such a manner as to forever preclude the possibility of its use for other purposes."

This brief review of the history of the creation of the Boston park system shows conclusively that one of its original and never-forgotten purposes was the utilization of the tidal basin of the Charles River by means of embankments, dams or otherwise, as an integral part of the completed scheme.

In 1891 the mayor of Boston, in his inaugural address of January 5,* recommended the creation of a water park out of the river basin by imitating the plan adopted in Hamburg, — that is, by damming the stream at the narrowest point. In view of the many private interests involved at that time (most of which have since disappeared by expropriation), a State commission was recommended to consider the whole subject; and by St. 1891, c. 390, a special commission was authorized to "consider the improvement of the basin between the Charles River bridge and the Watertown dam," and $3,000 were allowed for its expenditures.

This commission made two reports; the first being House Doc. 197 of the year 1892, and the other being House Doc. 924 of 1893. The second report is also to be found in the nineteenth annual report of the Boston Park Commissioners for 1893–94 (City Doc. 25 of 1894), at p. 56. The Charles River Improvement Commission, as appears from its first report, accepted without inquiry the theory of tidal scour; made no independent investigation of the subject, hav-

* City Doc. 1 of 1891, p. 16.

ing, indeed, no funds for the purpose; and, in view of the important commercial interests then located on the banks, recommended the reconstruction of the railroad and other bridges at such a height as to permit a much freer navigation of the river than was then possible. The second and final report of this commission recommended still more specifically the discontinuance of the railroad bridges and their concentration in a new high-level bridge, to be built without a draw. Both reports recommended embankments along the river, to be constructed at the public expense. The objection made by the railroad companies to the expense involved in the proposed reconstruction of their bridges was sufficient to prevent any State legislation such as was recommended by the commission; and the opposition of the United States War Department to the construction of drawless bridges prevented the city from building in that manner the new Charlestown bridge, authorized by St. 1894, c. 548. The work of this commission may therefore be considered to have been wholly fruitless; and that part of their first report in which the scour of the river was assumed, without special investigation, to be necessary for the maintenance of the harbor, was not regarded as conclusive; for the very next year a reinvestigation of the problems involved in the improvement of the river was entrusted to another State commission.

In the meanwhile the Legislature of 1892, upon the petition of the communities interested in the matter, passed an act (c. 342) authorizing the appointment of a commission to consider the establishment of a system of public parks in the metropolitan district. This commission made an elaborate report (House Doc. 150) to the Legislature of 1893, and by c. 407 of the Acts of that year a permanent Metropolitan Park Commission was created, with authority to take property for public park purposes. The report of the preliminary commission of 1892, a most careful and thorough discussion of the whole subject, laid great stress on the necessity for incorporating the Charles River basin in the proposed system of metropolitan parks.

By c. 475 of the Acts of 1893 (enacted within seven days of the passage of the metropolitan park act) the newly created Metropolitan Park Commission and the State Board of Health, sitting as a Joint Board, were directed to "investigate the sanitary condition of the river between the Charles River bridge and Waltham, and to prepare plans for the improvement of the same."

It was thus recognized from the outset, in the case of the metropolitan, as it had been in the case of the Boston parks, that the emparking of the Charles River basin was, if practicable, a desirable and essential part of the system; and it was considered that the changes in the situation caused by the contemplated expropriation of the river banks were sufficient to justify the Legislature in treating the findings of the commission of 1891 as inconclusive.

The Joint Board, which comprised among its members Dr. H. P. Walcott and Mr. H. F. Mills, the eminent hydraulic engineer, acting upon the advice of Mr. F. P. Stearns, the engineer of the State Board of Health, and of Messrs. Olmsted & Eliot, the landscape architects (one of whom, Mr. Charles Eliot, had signed the report of the Charles River Commission in 1892, hereinbefore referred to), reported in favor of the construction of a dam a short distance above Craigie bridge, and the maintenance of a permanent fresh-water basin behind the dam, with a constant water level about grade 8.

This report aroused great and not unreasonable opposition from the owners of property on the water side of Beacon Street, because of the suggestion to fill in a strip 300 feet in width upon the north side of these houses, and to sell the same for house lots, thus cutting off the residences on Beacon Street from a view of the river. Whatever may be the legal rights of the parties, there can be no question that for the State to fill in this strip and utilize it for building purposes would have been a breach of faith with those who had bought land on the water side of Beacon Street, and improved it, in reliance on the grants of the Commonwealth to the Boston & Roxbury Mill Corporation and others, and on the provisions of St. 1840, c. 35, § 6.

The plan of the Joint Board also seemed to many persons, who would otherwise have favored the construction of a dam, as objectionable by reason of its inelasticity, and because no clearly adequate means were provided for emptying the basin and refilling it with salt water, in case it should prove temporarily or permanently obnoxious as a fresh-water basin. This reason influenced the city authorities, who at the time were favorable generally to the damming of the river, to withhold their assent to the proposition put forth by the Joint Board. See Record, pp. 288, 289.

The report of the Joint Board was submitted to the Legislature in April, 1894, and upon June 9 of that year a resolve

was passed (c. 85) directing the Board of Harbor and Land Commissioners "to inquire into the construction of a dam and lock in the tidal basin of the Charles River, as proposed in the report of the Metropolitan Park Commission and the State Board of Health, sitting as a Joint Board, with special reference to interference with tide water and its effect upon the harbor of Boston," and appropriating the munificent sum of $1,500 for the expenses of the inquiry. At the hearings given by this Board all the facts and arguments that could tell against the project were ably and exhaustively presented by the counsel and experts retained by Mr. L. S. Dabney and other residents on the water side of Beacon Street; the authorities of Boston were, for the reasons given above, unwilling to favor the construction of a dam "as proposed in the report" of the Joint Board; and the presentation of the case for the dam was left to the municipal authorities of Cambridge, Watertown and Newton. No appropriation was made by either of these communities for expert investigation of the questions involved, and their evidence consisted of little more than the report of the Joint Board and the opinion of its professional adviser.

The appropriation voted by the Legislature to the Board of Harbor and Land Commissioners for the expenses of the inquiry, being only $1,500, was of course ridiculously inadequate to a proper investigation of the questions involved; no additional appropriation was requested; and no investigation was therefore made into either the sanitary or the tidal questions involved in the damming of the river, either by the commissioners themselves or by any engineer or expert on their behalf. The report of the Board was, as might be expected from the circumstances, inconclusive. Upon the sanitary aspects of the problem the commissioners were (p. ix) "unable to say . . . that the conclusion of the Joint Board may not justify the experiment;" and as to the damage likely to be done to the harbor through the reduction of the tidal prism, the Board found itself (pp. xix and xx) "powerless to say, on the imperfect information it has, what effect a dam as proposed would have on shoaling in the upper harbor," stated that further observations and investigations were essential to a definite and correct opinion on this question, and concluded that it was "unable to report in favor of" the construction of such a dam as the Joint Board proposed.

The report of the Harbor and Land Commissioners was possibly all that could be expected from a Board authorized to expend only $1,500 in the task, — or less than the prob-

able expense of printing the record, — but was, of course, satisfactory to no one. It was inconclusive on the face of it; it was not hostile to the project, so far as the sanitary effects of a fresh-water basin were concerned; and as to the question of tidal scour it was favorable rather than otherwise to the project, in so far as the conclusion was reached that neither the earlier theories of the United States engineers nor the opinion of Mr. Stearns should be accepted without a careful reinvestigation of the entire subject.

At or about the same time Mr. A. M. Mattice, formerly of the Engineer Corps U. S. Navy, was engaged by the city of Cambridge to investigate the question, and reported in favor of the project. His work covered most of the sanitary and hydraulic questions connected with the problem, including sewerage and scour.

The report of the Harbor and Land Commissioners had no effect upon the movement for converting the basin into a park. During the next few years the Commonwealth (acting under the provisions of St. 1894, c. 509) and the city of Cambridge (acting under St. 1892, c. 341; 1893, c. 337; 1896, c. 320; 1896, c. 508; and 1897, c. 469) continued the work of expropriating the shore for public uses, with the result that by 1902 there were only about half a dozen private estates between West Boston bridge and the Watertown dam, with riparian or navigation rights in the river. Record, pp. 29, 30.

In 1898 the Legislature authorized (by c. 467 of the Acts of that year; see also St. 1899, c. 180) a rebuilding of the West Boston bridge without a draw; and this mode of construction — which had been rejected by the War Department so recently as 1894 in the case of the new Charlestown bridge — was sanctioned by Congress (see Act of March 29, 1900), upon condition that compensation be paid to persons damaged in their property thereby. This condition has been complied with by the Legislature, which in 1902 passed an act (c. 464) compelling the cities of Boston and Cambridge to pay all damages sustained by those owning wharves along the river on March 29, 1900, "to such property by reason of interference with the access by water thereto enjoyed on said March 29, 1900, and theretofore, because of the construction of said bridge without a draw in accordance with the condition contained in the Act of Congress approved March 29, 1900." When this bridge is completed, the Charles River will be forever closed to masted navigation above West Boston bridge.

Within three years after the abortive investigation by the Harbor and Land Commission the project for a dam across the river was again brought forward, and the Legislature of 1898 passed an act (c. 531) authorizing the erection of such a structure at a point in the river a short distance below the Grand Junction Railroad. This plan would have secured none of the advantages to be gained by building a dam below West Boston bridge, was satisfactory to no one, and nothing was ever done to carry it out.

For legislation relating to the improvement of the river above the Watertown dam and the work done under it, see St. 1894, c. 529; St. 1900, cc. 340, 461; the report of the Joint Board to the Legislature of 1896;* and the annual reports of the Metropolitan Park Commission.

This brings us to the legislative session of 1901, when, on the petition of Mr. Henry L. Higginson and over seven thousand other residents of Boston and vicinity, the resolve (c. 105) was passed under which this committee is sitting. It was accepted, as required by its terms, by the cities of Boston and Cambridge on June 25, 1901, and July 3, 1901, respectively.

II.—The Advocates and Opponents of the Project.

Among those who on various occasions during the past ten years have advocated the conversion of the Charles River basin into a fresh-water reservoir or park by means of a dam, provided such a basin can be maintained without injury to the harbor or to the health of the community, we note the following:—

The city governments of Boston, Cambridge and Newton. See order of city council of Boston, passed Jan. 13, 1902; order of city council of Cambridge, passed Nov. 14, 1894 (H. & L., p. 893); and order of city council of Newton, passed Oct. 12, 1894 (H. & L., 903, and App., xlii).

The selectmen of Watertown. See H. & L., p. 975, and vote of Jan. 15, 1902 (Record, p. 25).

Every mayor of Boston and Cambridge since 1890.

The State Board of Health. See Joint Board.

The Metropolitan Park Commission. See Joint Board, and Record, pp. 25, 31–34.

The Boston Board of Health. See Record, p. 371.

The Cambridge Park Board. See annual report for 1894.

The Cambridge Club. See H. & L. App., xl.

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* Printed, but not numbered as a public document, under Resolves of 1896, c. 27.

The Citizens' Trade Association of Cambridge. See H. & L., p. 217.

The Young Men's Assembly of Watertown. See H. & L. App., xxxviii.

The Massachusetts Civic League, representing five hundred petitioners from the crowded sections of the city. See Record, p. 133.

The commanding officer of the U. S. Arsenal. See Record, p. 38.

The Citizens' Improvement Association of Ward 25, (Brighton). See H. & L., p. 878.

The Garden City Improvement Society of Newton. See H. & L. App., xxxix.

The Massachusetts Association of Boards of Health. See H. & L. App., xxxix.

The Cambridge Medical Improvement Society. See H. & L. App., xl.

The pastors of the North End churches, including the Very Rev. Vicar General Byrne (Record, p. 136), and the Rev. C. W. Duane of Christ Church.

The leading newspapers published in the metropolitan district.*

Over seven thousand residents in the vicinity of the proposed basin, including: —

Patrick A. Collins.
Thomas J. Gargan.
Prof. W. T. Sedgwick.
R. A. Woods of the South End settlement (Record, p. 145).
Samuel Hubbard of the North End Union (Record, p. 148).
Edwin D. Mead.
Rev. Geo. C. Lorimer.
Hon. S. L. Powers.
Judge Fallon of the South Boston Municipal Court.
Rev. S. H. Winkley.
Rev. W. C. Winslow.
Rev. S. D. Weber.
Rev. E. A. Horton.
Rev. Reuben Kidner.
Rev. J. McG. Foster.
Rev. James Eels.
Rev. T. F. Wright.
Rev. Dillon Bronson.
The Boston Towboat Company.
President Eliot (Record, p. 134).
Ex-Congressman Fitzgerald (Record, p. 139).
Bishop Lawrence (Record, p. 137).
Lucius Tuttle.
Chas. Francis Adams.
Robert Treat Paine.
Dr. John G. Blake (Record, p. 149), and one hundred other Boston physicians. (See *infra*, p. 528.)
Frederic Warren of the Warren Steamship Company.
Patterson, Wylde & Co., Agents Hamburg-American Steamship lines and the Johnston Steamship line.

* See editorial and other articles supporting the project in the "Boston Herald" of Feb. 3 and May 6, 1901; the "Boston Daily Globe" of Jan. 15, 1902; the "Boston Daily Post" of March 27, 1901; the "Boston Daily Transcript" of June 20, 1901; the "Boston Daily Advertiser" of Jan. 16, 1902; the "Watertown Enterprise" of Jan. 17, 1902; the "Arlington Advocate" of Jan. 18, 1902; the "Somerville Journal" of Jan. 24, 1902; the "Cambridge Tribune" of Jan. 18, 1902; the "Cambridge Times" of Feb. 7, 1902; and similar articles which appeared when the report of the Joint Board was under discussion.

John H. Child, Agent Red Star Steamship line.

Dr. Elbridge G. Cutler and twenty-three other residents on the water side of Beacon Street.

E. W. Burdett and eleven other residents on the water side of Bay State Road.

A. S. Porter and others residing on Brimmer Street.

The foregoing names are fairly representative of the truly popular character of the movement which has culminated in this investigation. We need only refer to the reasons given by such of these gentlemen as addressed the committee (see Record, pp. 133–152), and to the several hundred letters,* handed in but not printed in the record, to dispose of the frivolous suggestion in the brief submitted for Mr. Dabney and others that only the rowing interests of Harvard University would be benefited by the proposed basin. Boston is unfortunately a tenement-house city; the chief benefit of the proposed water park will accrue to the overcrowded population of the North End, the South End and East Cambridge; and it is those who are familiar with these conditions who are most anxiously awaiting the execution of this long-delayed improvement. It is not too much to say that there are five hundred thousand persons living in the valley of the Charles River whose health, morals and recreation would be measurably enhanced by the conversion of the present foul and unsightly estuary into a water park; and they and their physicians, pastors and political representatives are practically a unit in favor of the dam.

The chief remonstrants, to-day as in 1894, are certain gentlemen living on the water side of Beacon Street and certain wharf owners on the Cambridge side of the river.

The position of the Beacon Street remonstrants has, however, changed somewhat since the investigations of 1894, and their present attitude is rather sceptical than hostile. They even suggest a half-tide dam as a compromise measure. See statement of Mr. L. S. Dabney, Record, p. 328; brief for remonstrants, Record, p. 481. Many of the residents † on the water side of Beacon Street are, however, convinced that a high dam will be the best solution of the problem.

* We refer particularly to those written by Messrs. Chas. Francis Adams, U. H. Crocker, W. H. Manning, Henry Wyman, L. P. Hollander, Dr. John B. Bowen, Dr. Wm. H. Conant, J. E. Stanton, A. L. Rotch, W. P. Murray, Jos. A. Willard, Dr. L. M. Chamberlain, Dr. E. M. Hartwell, Dr. F. M. Johnson, Gordon Dexter, B. W. Palmer, C. H. Walker, Chas. Eliot Norton, Rev. Jas. Eels, J. P. Quincy, Dr. Wm. L. Richardson and John H. Child. See also the statements of prominent citizens at the investigation of 1894. H. & L., pp. 12–67, 597–644, 647–668, 706–863.

† Including Messrs. Henry S. Hunnewell, Robert C. Hooper, Geo. C. Lee, Gardiner M. Lane, J. H. Lee, D. L. Webster, Edgar Harding, and Doctors Chas. A. Porter, Geo. J. Englemann, Elbridge G. Cutler, E. H. Bradford, John B. Blake, Morton Prince, Hugh Williams, John W. Farlow, Oliver Wadsworth, Vincent Y. Bowditch and others.

The Cambridge wharf owners are much less numerous than in 1891, when their opposition seemed of overshadowing importance. Their interest in the free navigation of the Charles has been minimized by expropriation and by the reconstruction of the West Boston bridge without a draw. If the construction of a dam below that bridge would cause damage to the few riparian owners above the bridge, such damage would be inconsiderable in the aggregate, and following the precedent set by Congress with reference to the drawless bridge, might be charged to the cost of the dam. The opposition of the two or three remaining wharf owners above West Boston bridge will never be allowed to stand in the way of the transformation of this basin into a water park if that is desirable on other grounds; the building of the dam will benefit rather than injure them (see letter from the manager of the Boston Towboat Company, Record, p. 471); and all questions (except that of the precise site of the dam, as to which see below, p. 505) raised by these gentlemen may be dismissed with the suggestion that, if the committee or the Legislature think they should receive compensation, this can be provided without appreciably increasing the cost of the work.

There is, in short, no serious opposition to the present proposition, provided that good sanitary conditions can be assured, and that no danger to the harbor is to be apprehended. It is not too much to say that no public improvement in this Commonwealth has been so universally favored and so little opposed; that the communities bordering on the river are wholly in favor of transforming what is to-day little better than a mudhole into a water park of constant level; that the benefit to the people of such a park will be incalculable; that its cost will be insignificant;* and that no other community in the world, having a similar opportunity, would hesitate to seize it.

III. — The Present Proposition in Detail.

The concrete form in which the proposition may now be stated, after the elaborate investigation of the subject made by the sanitary and hydraulic engineers retained by the petitioners, is as follows: —

It is proposed to substitute for the unsightly and unsanitary conditions now existing in the tidal estuary, which has largely ceased to be valuable for commercial purposes, a water park or basin similar to that which has made Hamburg the most

* See below, p. 504.

beautiful and attractive modern city in the world; to accomplish this purpose by the construction at some point below West Boston bridge of a dam capable of being so operated as to secure for the basin above it either fresh water or salt water, or such combination of both as experience may show to be best, from the stand-point of sanitation; and to maintain the water in the basin at such a level, either constant or fluctuating, and to change it as frequently as experience may show to be desirable.

The present proposition is not that recommended by the Joint Board in 1894. While not differing from the conclusions reached by that Board as to the improbability that such a structure as was designed by Mr. Stearns would prove obnoxious to the public health, our engineers have adopted a type of dam which would permit a much greater flexibility of operation than that which was considered by the Joint Board, and afterwards by the Board of Harbor and Land Commissioners.

The structural and mechanical details of the type of dam suggested by the petitioners are fully explained in the testimony of Messrs. Blake and Shedd (Record, pp. 191–196, 235, 236, 240–244, 246–250, 252–255, 263, 265–270, 272–277, 280–282, 368), and in the plans and diagrams submitted by them to the committee.

The two designs are submitted as alternative suggestions. There can be no serious mechanical difficulty in designing sluice-gates adapted to any mode of operation; and if our designs are considered by the committee inadequate, it will be easy for its engineers to suggest some type which will be satisfactory. We believe, however, that either type of sluice-gate — either that designed by Mr. Blake or that designed by Mr. Shedd — will be found to operate satisfactorily. Either scheme will empty or fill the basin, we understand, in a single tide; and, if a still greater discharging area is thought desirable, the number and cross-section of the gates can be increased indefinitely.

So, of course, as to the dimensions and number of openings for the lock, wasteway and regulating ports; these can be increased in number or varied in construction, as this committee or the engineers who shall be placed in charge of the actual construction of the dam, may determine to be best.

A basin supported by a dam constructed as proposed will be capable of operation in various ways: —

(1) As a fresh-water basin, with a substantially constant water level at grade 8, as proposed by the Joint Board.

(2) Mainly as a fresh-water basin, but supplemented from time to time by the introduction of salt water, as may be found desirable. This plan was also suggested by the Joint Board, but has been worked out in greater detail by Mr. Blake, and can, we think, be carried out much more effectively by means of his plan than with the type of structure proposed by the Joint Board.

(3) As a half-tidal reservoir, like that controlled by the Richmond dam in London; the water level being never allowed to fall below say grade 5, but rising to the full limit of the flood tides. The water in such a half-tide basin could be renewed: (*a*) with every tide; or (*b*) on every other tide; or (*c*) less frequently still, as those in control of the dam may deem most convenient to the public.

(4) As a half-tide reservoir, limited both as to outflow and inflow, so that the water level shall never fall below say grade 5 or rise above say grade 8. And the water in this type of basin could be renewed either: (*a*) twice each day; or (*b*) once each day; or (*c*) less frequently, as above.

(5) Either as a constant level basin or with a fluctuating water level.

(6) As a fresh-water basin, except during a particularly dry period of a dry year, when the basin can be filled, as often as desired, with salt water.

(7) Finally, the dam could be so constructed as to permit of operating the basin upon many combinations of the foregoing elements not herein suggested; the idea being to provide a structure which will render it possible to provide behind the dam such an amount of water and such renewals thereof, whether salt or fresh, as experience may determine to be required for the convenience and health of the communities bordering on the basin.

We ask the committee to note the difference between the present proposition and the type of dam suggested by the Joint Board. These differences were explained by Mr. Blake (Record, pp. 235, 236), and sufficiently appear from an inspection of the plans themselves. The lock suggested by the Joint Board was not so deep; the regulating ports were not so large or deep, their discharging area being smaller by at least 30 per cent.; there was no wasteway; and there were no sluice-gates. It was therefore impossible to empty the basin quickly or to fill it quickly with salt water. The dam proposed by the Joint Board would not permit the operation of the basin as a half-tide or wholly salt-water reservoir.

On the other hand, the dam now proposed could be used to maintain either a purely fresh-water basin, or, if that should ever prove temporarily or permanently obnoxious, the fresh water could be let out to the extent and at the rate that might be desired, and salt water could be introduced in any quantity and as frequently and rapidly as necessary.

The advantage to the basin as a water park would be greatest if the water were kept fresh all the time; and we entertain no doubt that a purely fresh-water basin will prove entirely sanitary, and a vast improvement over present conditions. See below, p. 528. An occasional or even frequent change of the water level between grades 8 and 5 would, however, but slightly affect the convenient use of the basin; and, even if the basin were at times to be completely emptied, the inconvenience would be but temporary.

It is understood, of course, that the plans submitted by us are not supposed to exhaust the subject. The end in view — flexibility of operation — could doubtless be secured by a dam differing from ours in the details of construction, as well as in appearance; and the investigations of this committee or those of the Board charged with the construction of the dam may well result in modifications and improvements of the plans prepared by Messrs. Blake and Shedd. These plans are submitted merely as proof that the object in view can be secured without encountering great structural or financial difficulties.

IV. — The Cost of the Dam.

Mr. Blake estimates the cost of the dam designed by him, if located at the bend in the river just above Craigie bridge or at a point just below West Boston bridge, at $900,000; and if located at the site of Craigie bridge, and so built as to make a new bridge 120 feet wide, at $1,300,000; including in both cases $225,000 for the tidal sluices. Record, pp. 236–239.

City Engineer Jackson estimates the cost of the new bridge, which must soon be built in lieu of the worn-out and inadequate structure known for many years as Craigie bridge, at from $1,000,000 to $1,250,000, including approaches. Record, p. 239. The new Charles River bridge cost $1,500,000. Record, p. 239.

Mr. Shedd estimates the cost of his sluice-gates at $163,500, or about $70,000 less than Mr. Blake's type. Record, p. 277.

In other words, the estimated cost of a dam and bridge, if built together on the site of Craigie bridge, is no greater than the estimated cost of a new bridge alone; and, as the latter is a necessity of the near future, anyway, the community, by building both together, will get the dam for nothing.

The cost of the special sewers which may be rendered necessary or advisable by the construction of the dam, and which but for the dam would not be necessary, is believed to be little or nothing, and will be much more than offset by the saving to the metropolitan park system and the cities of Boston and Cambridge in the cost of the walls and embankments, dredging, etc., which will be necessary if the dam is not built. See Blake, *infra*, pp. 544, 545.

V.—The Location of the Dam.

The obvious site for the dam, from the stand-point of expense, is thus at Craigie bridge, which must soon be rebuilt, and which, if rebuilt as a dam, will cost no more than if rebuilt as a bridge.

This will also be the most convenient location; but the petitioners concede that the commercial interests along Broad and Lechmere canals must be considered, and that the dam should be placed above Broad canal and just below West Boston bridge, unless it can be located at or near Craigie bridge without irreparable injury to those interests.

The petitioners believe that the navigation of these canals and of the basin generally will be much improved by the construction of a dam at Craigie bridge, and the maintenance of a constant water level approximately at grade 8 above the dam; provided the dam is fitted with a suitable lock, that the canals are deepened, that they, as well as the lock and adjoining parts of the basin, are kept free from ice, and that the cost of any strengthening or reconstruction of the wharves along the canals is charged to the dam. See evidence of Mr. Blake and the letter from the manager of the Boston Towboat Company, Record, p. 471.

Counsel for the petitioners and counsel for the wharf owners have agreed—subject, of course, to the approval of the committee—as to the provisions which ought to be inserted in an act authorizing the construction of the dam if located at Craigie bridge. Record, pp. 465, 466. We understand that the expression "permanent water level" of the basin (which by the agreement is "not to be below grade 8") means the customary level, with a reasonable latitude

for such slight fluctuations or occasional emptyings as may be advisable in the operation of the basin.

The bridge of the Boston & Lowell Railroad leading to the Minot Street freight houses is perhaps too near Craigie bridge to allow sufficient manœuvring space, if that bridge is to be converted into a dam; but an investigation of the changes now being made in the Boston & Maine yards on the north side of the river in connection with the abolition of certain grade crossings indicates that the Lowell freight bridge can, without inconvenience to the railroad company, be relocated so as to leave a clear space of 300 to 400 feet between it and the proposed dam at Craigie bridge. This change, we understand, will leave ample space below the dam for vessels waiting to pass the lock.

VI.—The Question of Tidal Scour.

In the reports of the various boards or commissions who had occasion between 1835 and 1866 to consider, at the instance of the State and city, the condition of Boston harbor, the opinion was constantly expressed that the harbor channels were kept from filling or shoaling by the daily flow of the tides, that the estuaries above the harbor were essential to effective tidal action in the ship channel, and that any encroachment on these tidal reservoirs, particularly on those of the Mystic and the Charles, was certain to be followed by injury to the channel unless offset by compensation in kind,—that is, by an equivalent amount of excavation in other parts of these reservoirs.

The State Board of Harbor Commissioners, established by St. 1866, c. 149, and its successor, the Board of Harbor and Land Commissioners, by St. 1879, c. 263, adopted in a general way this theory, modified, however, so as to permit of dredging in the channel itself in lieu of compensation in kind for encroachments on the area of the inner basins.

Similar views were expressed by several engineers at legislative hearings in 1869 (City Doc. 128 of 1869) and 1871 (House Doc. 413 of 1871); by Major Raymond of the Corps of Engineers, U. S. A., in 1885 (H. & L. App., iii); by the Charles River Improvement Commission of 1891 (*supra*, p. 493); and by several witnesses before the Harbor and Land Commission at the investigation of 1894.

All the arguments for the belief in tidal scour as the best or only means of preserving the depth and width of the ship channels of Boston harbor will be found in the several reports

of the State Commissioners on Boston Harbor, between 1835 and 1852,* and in the ten or more reports made between 1860 and 1866 by the United States Commissioners on Boston Harbor, appointed by the government at the request of the mayor and city council of Boston.† The opinions expressed since 1866 in favor of the applicability of this theory to this harbor have all been professedly based upon the investigations made prior to that date by the State and United States commissioners, and not on later, different or fuller information.

These views have been adopted in part only by the public authorities, city, State and federal; and the process of encroachment on the natural area of the interior basins of the harbor, begun in the early part of the nineteenth century, has been persistently continued, until at the present time the original area of the basin with which this inquiry is concerned — the Charles River basin — has been reduced by about 75 per cent. Record, p. 193.

In the mean time, the chief exponents of the theory were losing faith in it (*infra*, p. 515); the city engineers of Boston completely discarded it (Record, p. 289 ‡); the United States engineers in 1889 were unwilling, owing to insufficient data, to formulate "a satisfactory theory of the action of the forces in operation," until the subject could be more thoroughly investigated (report of Chief of Engineers to the Secretary of War for 1889, p. 602); and when in 1893 the question was restudied for the first time since 1866 by competent engineers (Messrs. F. P. Stearns, Hiram F. Mills and Albert F. Noyes, acting for the State Board of Health), the conclusion was reached that the construction of a dam at the mouth of the Charles River would in no wise tend to create shoals or other obstructions in the harbor below.§ Then, when the work of the Joint Board

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* The reports of the several State Boards of Commissioners on Boston Harbor will be found, together with a number of legislative committee reports, in the House and Senate documents for 1837–52. The substance of these reports was reprinted in an appendix to City Doc. 60 of 1853.

† City Doc. 64 of 1859; 34, 37, 88, 97 of 1860; 12, 62, 63 of 1861; 53 of 1863; 33, 34 of 1864; 28 of 1865; and 50 of 1866.

‡ The statement of counsel on p. 289 of the Record is corroborated by the following letter from City Engineer Jackson: —

CITY OF BOSTON, ENGINEERING DEPARTMENT,
50 CITY HALL, Dec. 1, 1902.

HON. NATHAN MATTHEWS, Jr.

DEAR SIR: — In reply to your inquiry as to the effect of the flow of the "tidal prism" of the Charles River basin on the main channels in Boston harbor, I am of the opinion that the currents produced by the Charles River basin "tidal prism" have had in the past and have now no practical value either in the formation or in the maintenance of the main channels in Boston harbor.

Yours truly, WILLIAM JACKSON,
City Engineer.

§ See Joint Board, pp. 18–22; and H. & L., pp. 479–564, 854–863.

was reviewed by the Harbor and Land Commission in 1894, notwithstanding the fullest restatement of the scour theory by the counsel and engineers retained by the Beacon Street remonstrants and by former members of the Board, the commissioners found themselves unable to foresee "the consequences of building the proposed dam," and reported that further investigations — for which the commissioners had neither time nor money — were necessary before reaching a conclusion (H. & L., xv, xvi, xix, xx).

Late in 1894 Mr. A. M. Mattice, formerly of the Engineer Corps, U. S. N., investigated the subject for the city of Cambridge, and reached the conclusion that tidal scour was of little or no value in maintaining the harbor channels. Mattice, pp. 28–35, and H. & L., 752–775.

And now, at the hearings before this committee, although the chief remonstrants are the same gentlemen (Messrs. Dabney, Head and others) who, through counsel and witnesses, relied so much on this theory at the investigation of 1894, no one has appeared to protest against the damming of the river on the ground that the result would be injurious to the harbor. The remonstrants' brief "does not undertake to deal with this question" (Record, p. 487), and Mr. Dabney's remarks (Record, pp. 312–315) are merely an explanation — entirely unnecessary, in view of the literature on the subject down to 1894 — of the reasons why he and his associates came to lay so much stress on the scour theory at the hearings before the Harbor and Land Commission. The Citizens' Association of Boston and the Associated Board of Trade, the most influential of our local organizations, were strong remonstrants in 1894, on the ground of probable injury to the harbor (H. & L. App., xxii–xxviii and xli); but are not remonstrants at the present time. Many of their members, on the contrary, are now among the petitioners for a dam. The Boston Chamber of Commerce, which has been most active in furthering the interests of commerce at this port, is represented on the present occasion by counsel; but is apparently content to let the decision of the question turn upon the opinions of Messrs. Blake and Shedd, supplemented by such investigation as the committee may make. The agents of the Hamburg-American, Warren, Red Star and other steamship lines entering this port are in favor of the dam (*supra*, p. 499). So also the officers of the Boston Towboat Company (Record, p. 471). Finally, the Cambridge wharf owners, whose business also depends on the maintenance of adequate harbor channels, and who have been sufficiently interested in this inquiry to retain

counsel and attend all the hearings, have raised no objection to the construction of a dam on the ground of possible injury to the harbor. They have confined their criticism to the site of the dam, and have finally reached an agreement with the petitioners on this point also (*supra*, p. 505).

The whole theory may fairly be regarded as "exploded and abandoned" at the present time, even if that statement, when made in 1871, seemed somewhat premature (H. & L., xiii). In view, however, of the overwhelming importance to the community of an adequate harbor, and of the fact that none of the petitioners would favor any project which would injure the ship channel, they commissioned two of the most eminent hydraulic engineers in the country to investigate the subject *de novo*. The data collected by Messrs. Blake and Shedd, together with their conclusions, have been presented to the committee in the form of written reports printed in the record, supplemented by oral explanations and by numerous plans, diagrams and other illustrative material. Although no evidence or opinion has been submitted to the committee in opposition to the views of Messrs. Blake and Shedd, we assume that it is the purpose of the committee to examine for itself the validity of their conclusions, and in that work to restudy, in the light of present information, the data collected and opinions formulated by the State and United States Commissioners on Boston Harbor half a century ago.

As the contribution of counsel to this vital branch of the inquiry, we desire to present certain general considerations which seem to us conclusive against the applicability to Boston harbor in its present condition of the theory of tidal scour.

That theory, to state it again, comprises two propositions or deductions: *first*, that the existence of a tidal reservoir above the site of the proposed dam, and the flow twice daily of the tide in and out of this basin, are essential to the maintenance of the present depth and width of the ship channel between the Navy Yard and the open bay; and, *second*, that encroachments on this reservoir cannot be made good, having reference to the depth and width of the ship channel, by dredging in the channel itself.

It should be noted at the outset that the problem relates to the ship channel and not to the mouth of the river between the city proper and Charlestown, where, owing to the numerous wharves and bridges which interfere with the natural flow of the river and tide, some slight shoaling might

be expected to take place, whether the tide is stopped at Craigie bridge or not.*

The inquiry is also confined to this particular harbor, which is not to be confounded with other harbors different in origin and physical features, in which tidal action may admittedly be of great value in maintaining unobstructed channels.

The petitioners contend that, in view of the changes already effected and now under way in Boston harbor, that harbor will soon be a purely artificial creation; that, as it will have been created by dredging, it must be maintained by dredging; that, even if in a state of nature or at the present time the depth and width of the ship channel are in any manner dependent on the tidal prism of the Charles River, that force cannot be relied on to keep, or even to help to keep, the greatly enlarged channel of the future free from shoaling; that any conceivable loss of scour due to the closing of the basin can be much more than offset by a very small annual expenditure for dredging; that there is no scientific basis for the theory that the reservoir itself is helpful, by way of tidal scour, or otherwise, to the preservation of the harbor channels; and that, in view of all the conditions of the problem, present and prospective, the construction of a dam at or near Craigie bridge will prove a benefit rather than an injury to the harbor.

The theory of tidal scour, as applied to this harbor by the State and United States commissioners between 1835 and 1866, rests upon the investigations made by European engineers prior to 1840 into the conditions obtaining in various harbors in Europe, on the laboratory experiments of Dubuat, on the supposed ability of the river flow to give the ebb tide a material predominance over the flood, on certain local data collected by the commissioners themselves, and on certain assumptions as to the physical history of Boston harbor.

The conclusions of the foreign engineers were assumed to be of universal application, and no attempt was made to test the value for this harbor of Dubuat's conclusions by experimenting with the actual conditions of the problem.

The data collected by the commissioners themselves were admittedly meagre. We have already referred to the unwillingness of the United States Harbor Line Board of 1889 to dogmatize upon the subject (*supra*, p. 507), and to the

* As a matter of fact, however, little or no *net* shoaling, even in this part of the harbor, can be detected.

still greater reluctance of the Harbor and Land Commissioners in 1894 to commit themselves to the theory of tidal scour; but the earlier commissioners were themselves well aware of the inadequacy of the observed data as a foundation for their theory. The fifth report of the United States commissioners admits that all they could discover in this harbor were "traces of many causes rather than well-defined effects," * and the insignificance of most of the factors relied on was repeatedly conceded.

Thus, in the final report of the United States commissioners they refer to this harbor as being "fed by feeble land streams," and state that the back or river water is but "scantily supplied."†

As to the tidal currents, so important to the validity of the theory, the United States commissioners in their ninth report show that the average rapidity of the flow is only half a mile and the maximum one mile an hour, — much less than in other harbors; ‡ and say that: "Boston harbor, when contrasted with some other ports, may be said to be traversed by tidal drifts of a very feeble character." §

In their final report the currents are again referred to as "absent or feeble of action," and as "very sluggish." ||

Tidal currents, to produce an effective scour, must have a predominating down-stream resultant; ¶ but the currents in our ship channel neutralize each other in some places, ** and in others there is actually a strong predominance of the flood," †† which the commissioners in their final report characterize as "one of the worst features" of the harbor. ‡‡

It must be evident that such feeble and contradictory currents cannot produce much scour; and such is conceded by the commissioners to be the case. Thus, in their fifth report, they say that in certain parts of the channel the ebb currents are so "dissipated by the present excessive width of the tidal path as to have no scouring operation;" §§ and in their fourth report that: "There is not enough scour in the thread of the stream to ensure its remaining permanently free. . . . The heavier class of deposits can but accumulate." || ||

One would suppose that this admitted insignificance of river flow, tidal current and tidal scour would have caused the commissioners to hesitate before concluding that the preservation of the harbor depended on these factors; but no, — they consider the river water an "important element

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* City Doc. 63 of 1861, p. 26. † City Doc. 50 of 1866, pp. 9 and 53.
‡ City Doc. 28 of 1865, p. 18; and see City Doc. 50 of 1866, p. 56.
§ City Doc. 28 of 1865, p. 19. || City Doc. 50 of 1866, pp. 6 and 57.
¶ City Doc. 50 of 1866, p. 7. ** City Doc. 62 of 1861, p. 22.
†† City Doc. 63 of 1861, p. 27. ‡‡ City Doc. 50 of 1866, p. 76. §§ City Doc. 63 of 1861, p. 36.
|| || City Doc. 62 of 1861, p. 11. See also pp. 16, 20 and 22 of this report, and City Doc. 63 of 1861, p. 27.

in the preservation of the harbor channels," give to the tidal drifts "a very important place," * and assign to scour the chief role in the perpetuation of the channel.

Even the tidal basins themselves, the maintenance of which, undiminished in area and volume, is considered by the commissioners as essential to the depth and width of the harbor channels, are admitted in their final report to be "inadequate" and "insignificant." †

So far we have a theory resting on data which are admitted to be few in number and insignificant in import, and involving conclusions which do not seem to follow from the premises.

The next point that strikes us, as we read the commissioners' reports, is their failure to give due weight to the many admitted facts which make positively against the theory.

We have, in the first place, the character of the bed of the channel. This the commissioners admit to be composed of boulder clay and hard pan, which the currents have no power to move. ‡

Then the expansion of the harbor into a broad basin between the entrance and the city tends to minimize the tidal scour. In the fifth report of the United States commissioners we find it stated that: "The ebb currents from the basins of the rivers are dissipated by the present excessive width of the tidal path, and, being weakened so as to have no scouring operation, are obliged also to throw down their muds," etc.; § and in their final report this: "The too sudden expansion of the ebb stream (the compound of the Mystic and Charles River waters) after passing the strait between the city and East Boston is a grand source of mischief; for the power of this main stream is exhausted by the very act of divergence." ‖

But the commissioners fail to draw from this configuration of the harbor the logical inference, and continue to reason about the creation and preservation of the main ship channel as if it occupied a deep and narrow gorge, like Shirley Gut.

Another point to which the commissioners frequently direct our attention is the injurious effect in this harbor of the last run of the ebb tide; but they seem to ignore the difficulty of reconciling this fact with their theory that the ebb tide keeps the channel free.

In the seventh report of the United States commission-

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* City Doc. 50 of 1866, pp. 9 and 53. † City Doc. 50 of 1866, pp. 55 and 57.
‡ City Doc. 62 of 1861, p. 16; City Doc. 60 of 1853, p. 45. § City Doc. 63 of 1861, p. 36.
‖ City Doc. 50 of 1866, p. 57; and see *ib.*, p. 77, and City Doc. 62 of 1861, p. 10.

ers, is this statement by Professor Mitchell: "There is a positive injury to the basin of the upper harbor, resulting from the existence of excessive flats covered only by tide water (due to the scour of the flood but not to that of the ebb). . . . The lower stratum of the water in the channel which felt the direct influence of the flood is slow to act under the indirect influence of the ebb. . . . If you would add to the ebb scour in the upper harbor, let down the working plane by removing the flats." *

In their ninth report the United States commissioners say: "The ebb power, to act efficiently upon the main channel of the harbor, must be chiefly exerted during the first five hours." †

In their final report, ‡ speaking of the residual outflow at the time of low water, the commissioners say that it "breaks the order of the recurrent tidal epochs of the harbor below, and is injurious in the proportion that it acts as a conveyance of muds to the place of impact with the flood" (p. 28).

"Near the time of low water, when Boston harbor is but little agitated by currents, there flows from the South Bay and other shallow lagoons a number of muddy brooks, adding their contribution to the extension of marginal flats. These brooks are generally called guzzles" (p. 31).

"At the mouth of the harbor every part of the ebb current there existing is useful; but the ebb from the distant interior reservoirs on the last of the fall may not only be useless but hurtful at the harbor's mouth, by opposing the inflow. Its power comes too late for reinforcement" (p. 47).

"The upper harbor is hence the scene of conflicting, or at best that of opposing, forces, neutralizing each other at time of low water" (p. 55).

"For nearly one hour the basin of the upper harbor is either a vortex for opposing streams or a neutral ground for the deposit of sedimentary matter. It thus appears that the most valuable portion of Boston harbor is to be the seat of the most serious antagonism and the most feeble efforts of the tidal currents" (p. 69).

We have already seen that the scouring action of the tide on the main channel is conceded to be weak (*supra*, p. 511), and here we have repeated admissions that the tendency of the last two feet of the ebb must be to create shoals; but we find no evidence that the commissioners appreciate the inconsistency of these conditions with their conclusion that the ebb tide keeps the channels clear.

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* City Doc. 33 of 1864, p. 81. † City Doc. 28 of 1865, p. 15. ‡ City Doc. 50 of 1866.

We note also a failure to appreciate the significance of the changes brought about by artificial means in the physical character of the harbor. Much encroachment on the original area of the inner basins had taken place prior to the first report of the State commissioners in 1837, and still greater encroachments were permitted between that date and the final report of the United States commissioners in 1866. These encroachments were deplored in almost every report, but no evidence of any result injurious to the harbor was detected. Some slight shifting of material was observed, but no net shoaling clearly or even probably due to restriction of the tidal flow. In 1847 a committee of the State Legislature reported that there was "as great a depth of water in the harbor from Castle Island upwards as in 1761." * In the elaborate report of the special committee of the Boston city council in 1853, known as the Eldredge report, it is stated that up to that time there had been no change in the depth of water in the channel; † and in the annexed report of the city engineer, Mr. E. S. Chesbrough, it is said there has been "since 1835 . . . no perceptible diminution in the depth of the centre of the main channel," and that "there can be scarcely any doubt that the water is quite as deep as it ever has been since the first vessel sailed into the harbor." ‡ The United States commissioners in their fifth report were able to discover not so much "well-defined effects" as "traces of many causes;" § and in the second [annual] report of the State Board of Harbor Commissioners it is admitted that the volume of water in the channel was as great as ever. || Finally, the United States Advisory Council to the Board of Harbor Commissioners, consisting of Gen. A. A. Humphreys, Professor Benjamin Peirce and Professor Henry Mitchell, expressed the opinion in 1868 that the "volume of the upper harbor below mean low-water level was substantially the same from 1835 to 1861." ¶

Thus down to 1868 — a date subsequent to the final elaboration of the scour theory — none of the consequences of a diminution in the tidal prism had been observed which ought to have taken place if the theory were sound, and which it was freely predicted must take place.

The evidence collected on this point since 1868 proves conclusively — what was at least a fair inference from the facts noted prior to that date — that a diminution in the tidal prism is not followed by any shoaling in the main

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* Senate Doc. 63 of 1847, p. 1. † City Doc. 60 of 1853, p. 19. ‡ *Ibid.*, pp. 44 and 45.
§ City Doc. 63 of 1861, p. 26. || House Doc. 10 of 1868, p. 15. ¶ *Ibid.*, p. 83.

channels of this harbor (see *infra*, p. 524); but before considering the facts brought to light during the thirty-six years which have elapsed since the final statement of the scour theory by the United States commissioners in 1866, and passing by, for the moment, the mistakes of fact committed by these gentlemen (particularly the unaccountable exaggeration of the volume of the river current, — see *infra*, p. 523), we desire to call attention to the abandonment by the United States engineers of what they had themselves laid down as a necessary deduction from their theory.

If the preservation of the channel depends on the integrity of the tidal prism, it follows that no encroachment on the interior reservoirs should be permitted without equivalent excavations in other parts of these reservoirs, *i.e.*, without compensation in kind. Boston harbor, say the commissioners, cannot "afford to lose another cubic yard of tide water," * and their reports, particularly the last one made in 1866, contain elaborate arguments for the doctrine of compensation in kind. And when, as the result of this report, the State Board of Harbor Commissioners was created by St. 1866, c. 149, compensation in kind was prescribed as the price to be paid for all future encroachments on the tidal prism.

The question then immediately before the public was the filling of the South Boston flats, and the United States commissioners had, consistently with their theory, recommended as compensation for the occupation of these flats extensive excavations in the basins of the Charles and Mystic; but when the newly created State Board of Harbor Commissioners were confronted with this problem, they decided that these expensive excavations were unnecessary, and were supported in this opinion by their Advisory Council of United States Engineers. Taking advantage of a general clause, wisely (though probably not purposely) inserted in the act of 1866, the commissioners recommended, with the approval of the Advisory Council, the much less expensive method of dredging the ship channel itself, in lieu of compensation in kind. The United States commissioners had recommended that the State should lay aside the sum of $500,000 as a fund, the income of which should be expended on dredging in the channel, while the State commissioners now proposed that the State should dredge the channel to a depth of twenty-three feet at mean low water, but without raising any special fund for the pur-

* City Doc. 50 of 1866, p. 84. As early as 1852 the State commissioners had expressed the opinion that, "if any filling up should be allowed, an equivalent excavation higher up should be required," and that "no encroachment whatever on the tidal waters of the harbor should be allowed."

pose. Neither of these schemes was carried out, however; and, as a matter of fact, the South Boston flats were filled without compensation of any sort, — in kind, in dredging or in money. The history of this controversy will be found in House Doc. 10 of 1868 and House Doc. 13 of 1869, being respectively the second and third reports of the State Board of Harbor Commissioners; and in the minority report in House Doc. 413 of 1871.

The abandonment of the doctrine of compensation in kind was justified by the United States Advisory Council of 1868, on the ground that the congested condition of the mouth of the Charles River, due to the wharves and bridges, was so great as to render it unlikely that the harbor channels would reap the full benefit of the increase in the tidal prism to be secured from excavations in the inner basin proposed by the United States commissioners; but when Professor Peirce next had occasion, in 1871, to consider the question, he took a still more advanced position in favor of the channel dredge, saying that it would only cost $8,000 a year to maintain a depth of twenty-three feet in the upper harbor.*

Professor Mitchell went so far as to express a doubt whether "it would not be better to use the money directly on the channels" than to secure compensation in kind by excavating in the tidal reservoirs, even if the outlets were in a favorable condition; and, on being further pressed, stated emphatically that he would not advise any further excavation of artificial reservoirs.† This position of Professor Mitchell marks a wide departure from the opinion prepared by him for the final report of the United States commissioners.‡

Compensation in kind was properly held by the United States commissioners to be a necessary deduction from the theory of tidal scour as formulated by them; but it was no sooner adopted by the State in conformity with the advice of these commissioners, than it was overthrown by the State upon the advice of some of the very men who, but a few years previously, had been most confident in its behalf. With a few minor exceptions no compensation in kind has been exacted for the encroachments which in half a century have reduced the tidal prism of the Charles by 55 per cent. Record, pp. 193, 194. On the other hand, a compensation fund, collected chiefly for the extension of wharves, docks, etc., has been accumulated, and the income of this fund, now amounting to about $12,000 a year, is available

* House Doc. 413 of 1871, p. 39. † *Ibid.*, pp. 45, 47.
‡ City Doc. 50 of 1866, pp. 101-127.

for channel dredging.* This is 50 per cent. in excess of Professor Peirce's estimate of the amount required to keep the channel free from shoaling.

When we reflect upon the facility with which the United States engineers abandoned the doctrine of compensation in kind, previously held by them to be a necessary corollary of their theory of tidal scour; when we consider that no injurious results followed the occupation of the South Boston flats without compensation either in kind or in dredging, notwithstanding the predictions of the commissioners; that the equally emphatic opinions of the commissioners against the utilization of the Upper Mystic Pond as a source of water supply, and in favor of extensive excavations in the Lower Mystic tidal reservoir,† were wholly disregarded without perceptible injury to the channel; when we consider this conflict between opinion and results, and between the opinions expressed by the same engineers in 1866 and 1871, we can readily understand the hesitation of the scientific men of the present day — even if ignorant of the results of recent investigations — to accept the reasoning and conclusions of the commissioners who considered the subject between 1835 and 1866. Nor will the most careful perusal of their arguments help their case, for, without taking account of the assumptions of fact which later experience proves to have been unwarranted, their conclusions, as already noted (*supra*, pp. 510–512), were based on data admittedly inadequate and on factors conceded to be insignificant. Their theory was formed without regard to many facts of admitted importance which told against it; much of their reasoning was, to say the least, unscientific; ‡ and no attempt was made to test the applicability to this harbor of experiments made in other harbors of totally different conformation.

Their methods seem unscientific, their data insufficient, their conclusions paradoxical; and in the light of present information, we submit that the question is not so much whether the theory of tidal scour is applicable to the ship channels of Boston harbor, as how the many eminent engineers who served on the various commissions between 1835 and 1866 came to think that it was.

The confidence with which conclusions were drawn by these gentlemen from premises so inadequate has been a mystery to every one who has read their reports; and the

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* This fund on Nov. 30, 1902, amounted to $389,901.08. † City Doc. 28 of 1865, p. 11.
‡ Note, in particular, the instance to which Mr. Blake calls attention, in Record, p. 215.

mystery deepens when we contemplate their rejected recommendations, their unverified predictions, the change in the opinions of some of them, and the present state of the harbor, — so different from what it ought to be if their theory had been correct.

The answer to these questions, the solution of this mystery, is, we submit, beyond doubt to be found in the erroneous geological theories which were current in the early and middle parts of the nineteenth century, and which were accepted without suspicion by the engineers.

According to these theories, the original surface of Boston harbor and vicinity was an alluvial bottom, in which the channels and deeper parts had been excavated by the tides and rivers. The earliest reference to this theory in the literature of the subject under discussion is in the first report of the first commission appointed to investigate the condition of the harbor. These commissioners (Messrs. Loammi Baldwin, S. Thayer and James Hayward) use the following language on p. 17 of their report: * "Four Point channel is formed and preserved by the action of the current when the tide flows into and out of South Bay." On p. 21 they speak of the channels "produced" by the tidal current in the Mystic and Charles River and South Bay; and say that: "The harbor of Boston . . . is wholly made and continued as channels, through which the tides ascend into immense basins and rivers . . . and from which the tides descend again to the ocean, and in their progress scour out the channel according to the quantity and velocity of the current produced on the ebb. That part on the southeast, called Four Point channel, is thus made by the tide passing into South Bay, and the harbor on the north is only the channel through which the tide flows into the Charles and Mystic rivers to the head of tide water at Watertown on the first and Mystic Pond on the latter. . . . It is the channel produced by the strength of these alternate currents in opposite directions, into South Bay, or the great reservoirs of the two rivers, that constitutes all the advantages of Boston harbor for commercial purposes." And on p. 22: "Boston harbor being only a channel for the tide to flow in and out of the great reservoirs before mentioned . . . it is obvious to every reflecting man . . . that if a dam were to be built on the site where South Boston Free bridge or South Boston bridge now stands, and the tide pre-

* Senate Doc. 47 of 1837.

vented from flowing above, Four Point channel would soon be filled with sediment, and not be distinguishable from the surface of flats on the south-east side. Similar effects would also result from the erection of dams in place of Chelsea and Charles River bridge."

We have quoted somewhat at length from this report, because we have here the genesis of the scour theory and the proof that it was based upon the assumption that the harbor channels had been originally created by tidal scour, and because the passages here quoted are found repeated, usually without acknowledgment, in the reports of subsequent boards down to 1866.

The so-called Eldredge report of 1853 contains the following statement: "The channels of the harbor being formed and continued by the tide waters passing to and from the great reservoirs of the Charles and Mystic rivers and the South Bay, and the scouring or deepening effect of the tides in passing through the channels being in proportion to the quantity and velocity of the ebb, it follows as a natural result that any material reduction in the area of those reservoirs must necessarily reduce the quantity of water and diminish the velocity of the current and thus injuriously affect the channels." *

In the report of the State commissioners appointed under Resolves of 1854, c. 36, we find a repetition of the opinion just quoted from the report of 1853, and an independent opinion by the commissioners themselves, that "the channels of the harbor are formed and continued by the tide waters passing into and out of the great reservoirs." †

In a special report of the United States commissioners we find that they refer to the various kinds of harbor that are "peculiar to alluvial shores," and state that Boston harbor belongs to that class "of tidal harbors which owe their existence and maintenance to interior reservoirs and rivers combined." They go on to say: "The reservoirs and rivers inside it and above it constitute the original sources of its existence and the efficient means of its preservation." ‡

In their final report § they say: "We may divide into two classes the tidal harbors of our coast under the titles of inlets and arms of the sea. The former, occurring in alluvial regions, are usually barred by the action of the ocean waves; while the latter, occurring in rocky or less yielding shores, have a free access from the sea. . . . Both

* City Doc. 60 of 1853, p. 5.
† Senate Doc. 63 of 1855, pp. 9 and 12.
‡ City Doc. 12 of 1861, p. 28.
§ City Doc. 50 of 1866.

. . . agree in their dependence upon the working power of currents for the maintenance of their principal avenues" (p. 6).

"The main channel of the upper harbor of Boston is chiefly dependent for its depth and width upon its service as the avenue of supply and drainage for the basins of the Charles and Mystic rivers and Chelsea creek. Were these reservoirs closed, the larger part of this main artery would in the course of time cease to exist, for it is but the trench dug through the yielding bed of the harbor by the passage to and fro of the river and tidal waters" (p. 50).

"It is a very remarkable circumstance that the main ship channel here is traversed by no current along its course; and we have tried in vain to conceive by what disposition of forces it was first created. That it must once have been dug out by a tidal stream would seem evident from the form of its bed and banks" (note, p. 50).

Professor Whiting said to a legislative committee in 1871: "But for the fact of this reservoir existing and of the narrow outlets and the island contracting and forming the upper harbor as a basin, we should have had no deeper water than there is in Quincy Bay or other bays that have not this peculiar formation;" * and in 1894, before the Harbor and Land Commission: "I merely wish to allude again to the peculiar formation of Boston harbor and its excellence, and to the fact that this deep water has been — these deep channels have been affected and produced by the tidal — this excessive tidal current seeking these inner basins." †

Other references to this fundamental assumption are to be found scattered through the reports. ‡

We thus see that from their first report in 1837 to the final elaboration of their theory in 1866 the State and United States commissioners relied on the assumption that the channel was itself created by tidal erosion. Starting from this assumption, no great amount of evidence would be required to justify the conclusion that the natural forces operating in the harbor were in a state of equilibrium favorable to the maintenance of present conditions, and that, if the force which carved the channel out of the mud was removed or impaired, the other forces would gain the ascendency, and shoaling would result. Facts inconsistent with this conclusion might well be ignored if tidal scour was the physical and original cause of the channel itself; and the strongest

* House Doc. 413 of 1871, p. 62.

† H. & L., p. 227.

‡ See Senate Doc. 8 of 1840, p. 7; City Doc. 97 of 1860, pp. 21–23; City Doc. 108 of 1863, pp. 26, 42, 44; City Doc. 50 of 1866, pp. 73, 78; report of Harbor Commissioners for 1877, p. 18.

evidence might fairly be required to rebut the presumption that the causes which created the channel, and which were still in operation, were necessary for its preservation. The conclusion reached by the commissioners did not follow, logically, necessarily, or even presumptively, from the observed data; it did follow, as a matter of practical, if not of mathematical inference, from the assumption that the channels had been created by tidal scour.

As the commissioners of 1835 say, their conclusion "is obvious to every reflecting man," and follows "as a natural result;" or, as Mr. Geo. O. Shattuck said before a legislative committee in 1869, when arguing against the filling of the Charles River basin, we "need not argue, because it is too clear for argument," that such filling would do injury to the harbor, if we assume, as he did, that "the main channel of Boston harbor has undoubtedly been swept out in the course of ages by the waters flowing in and out of the tidal basins." * No argument was necessary, no evidence required; the deduction followed as a matter of course; and nothing but the strongest proof, which of course was lacking, would have justified a different conclusion, — if the underlying assumption that the channel had been dug out of the flats by the tides was sound.

We now know that this assumption was entirely erroneous, and not in accord with the knowledge we possess since the glacial interpretation has been adopted by all leading geologists and is confidently applied to the physical history of the New England sea coast. We now know that Boston harbor is not of alluvial or fluviatile origin. The outline of the harbor, so far as its natural form has been retained, and the general configuration of its bottom, represent simply the contours and inequalities of the land as it sank after the recession of the ice. The channels in the harbor are merely the lowest levels of the bottom as they were left by the agencies operative in the epoch preceding the present. They are, therefore, not a result of erosion by any currents now existing, either tidal or fluvial. We know that the river and tidal currents as we see them had no part in the creation of these channels; † but this knowledge was not open to the eminent engineers who considered this subject prior to 1870. See Professor Niles's report, *infra*, pp. 540, 541. The reports of the United States

* City Doc. 128 of 1869, p. 38.

† Whatever river erosion took place as the ice receded was due to the relatively enormous flow of the post-glacial rivers. These streams, however, ceased to flow many thousand years ago, and the conditions produced by them are not now maintained by the same forces acting with their old intensity, but simply because these forces have wholly ceased to operate.

engineers contain, it is true, statements which are more or less inconsistent with the doctrine of original erosion and of subsequent equilibrium. Thus the natural tendency of the tidal basins to fill up is admitted in the second and tenth reports of the United States commissioners,* without apparently suggesting to their minds any doubt as to the "equilibrium" elsewhere asserted to exist.† But in the then state of geological knowledge the commissioners are not to be criticised for having assumed a tidal origin for the harbor channels, as it was not until a comparatively recent period, certainly not before 1884, that full and clear information concerning the physical history of the harbor was available. *Infra*, p. 540.

The present state of geological information enables us to reconstruct the physical history of Boston harbor with much accuracy.

Professor Shaler's account, written in 1882, will be found in the Appendix to this argument. *Infra*, pp. 542–544.

The views of Prof. W. M. Davis are given in two letters printed in the Record, pp. 370, 371. He says, in substance, (p. 371) that it "may be stated with confidence that the United States commissioners were wrong in asserting that the channel of the upper harbor was simply a trench dug out by the passage of river and tidal waters;" and that "when the present level was assumed the outline and depth of the harbor"—the "original form" of the harbor—"were due simply to an occupation by an arm of the sea of the basins and troughs that then stood beneath the sea level."

A report by Prof. Wm. H. Niles is appended to this argument (*infra*, p. 540), and contains not only a description of the physical history of the harbor, as now understood by geologists, but also a chronology of scientific discussion relating to this subject.

The fundamental assumption on which the theory of tidal scour, as applied to this harbor, depended, having been shown to be unfounded, the theory itself must fall unless the independent facts and observations are sufficient to sustain it.

These data, or at least the facts collected down to 1866, when considered by themselves, independently of any particular assumption as to the origin of the harbor, were admittedly insufficient and inconclusive (*supra*, p. 510). To

* City Doc. 97 of 1860, p. 10; City Doc. 50 of 1866, p. 6.
† City Doc. 50 of 1866, p. 35; and see H. & L., ix.

our minds they pointed strongly to the conclusion that no diminution in the area or volume of the tidal reservoirs had or could have any effect on the ship channel whatever; but let us assume that the question was left open by the United States commissioners, and let us see what facts have been discovered or collected since 1866 which affect its decision.

The commissioners believed that the supply of river water added 10 per cent. to the duration of the ebb, and increased the velocity of the ebb over the flood by 30 per cent.* Now, the facts are that the increase in the duration of the ebb due to the river water is only 1.3 per cent., and that the preponderance in velocity of the ebb over the flood due to the river water (and coincident with the above increase of 1.3 per cent. in duration) is only 2.6 per cent. See Blake, Record, pp. 196, 212, 213; Shedd, *ibid.*, p. 349. Professor Mitchell's figures were deduced from a few observations of the currents, as to which he himself admits that "no current observations, however nice, can measure accurately that bodily movement of large masses of water which the propagation of the tide wave induces;" and he had at that time no precise knowledge of the actual volume of fresh water in the river. No attempt was made to measure the flow directly, and no general records, like those of the Sudbury, were then available. The estimates of the river flow made by Messrs. Blake and Shedd are based upon the Sudbury water-shed records, which, though universally accepted as accurate for this part of Massachusetts, were not begun until after 1872, and were of course not known to the United States commissioners or Professor Mitchell at the time when Boston harbor was under their consideration. It is, however, somewhat remarkable that the United States engineers should have over-estimated the volume and effect of the fresh-water flow — which is practically all that gives the ebb any predominance over the flood — by about one thousand per cent.

The resultant of the tidal currents has been restudied, and found to be much less favorable to the efficacy of the ebb than was supposed by the United States commissioners. Shedd, Record, pp. 349–351. It often runs across the channel, sometimes up stream, and seldom coincides with the thread of the channel.

Dubuat's experiments are no longer accepted without verification (Record, pp. 226, 352, 353); and the United States engineers have found in practice that the velocities given by him as sufficient to move solid materials must be doubled.

* City Doc. 33 of 1864, p. 52.

See report of Maj. C. B. Sears of the United States Corps of Engineers, written in 1876, Record, p. 352, and Journal Am. Soc. Civ. Eng., vol. V., p. 426.

Information concerning the bottom of the harbor has accumulated, showing hard clay and gravel drifts (where there is no rock), incapable of being moved by the tides. See Senate Doc. 303 of 1895, and report of Chief of Engineers, U. S. A., for 1891, p. 1107.

The conclusions of the United States commissioners as to the injurious effects of the last run of the ebb tide have been restudied, with the result that it now seems that there will be a distinct advantage in cutting off the last two feet of the ebb by means of a dam. Record, pp. 210, 214, 229, 249, 250, 351.

The effect of a dam in diminishing the volume of the flood tide has also been considered, with the result that several advantages are predicted as likely to be realized, including a diminution of the shoaling, or rather shifting of material, which now takes place (Senate Doc. 303 of 1895) at the mouth of the river above the main ship channel. Record, pp. 251, 358, 359.

The erosion of the headlands and islands by wave action has been stopped through the construction of embankments, finished in 1889. See report of Chief of Engineers, U. S. A., for 1901, p. 153. This wasting of the harbor islands and shores was apparently a possible cause of shoaling, and this cause has been entirely eliminated.

Finally, notwithstanding the encroachments on the tidal prism which have been permitted at various times during the past century, with the effect, so far as the Charles River basin is concerned, of reducing the same by 55 per cent. (Record, p. 194), no shoaling has in fact taken place in the ship channel. We have already called attention to the fact that the United States commissioners admitted that there had been no shoaling between 1835 and 1861 (*supra*, p. 514); and, although in their final report of 1866 they assert or assume that shoaling is, or must be, taking place, the evidence collected by the Harbor and Land Commissioners in 1895 (Sen. Doc. 303 of 1895) is conclusive that there was none between 1861 and 1892. There had been some shifting of material, but no net diminution in the depth or width of the main ship channel.

Particular attention is directed to the report of Mr. Frank M. Hodgdon, chief engineer to the Harbor and Land Commission, accompanying Sen. Doc. 303, as disposing completely of the belief or fear entertained by the United States

commissioners that the harbor channels were filling up. Mr. Hodgdon's comparison between the surveys of 1861 and 1892 was limited to those portions of the channel where there had been no dredging (pp. 3 and 4), and proves that there was no shoaling or filling between those dates. He also reports (p. 8) that the channels where dredging has taken place "maintain their depths, and it has not been necessary to redredge them" except in two cases some distance away from the main ship channel. His report also shows (pp. 6–9), more completely than any previous investigation, that the harbor floor is composed principally of clay, gravel, black sand and other glacial drift, with little or no alluvial silt.

The evidence given at these hearings confirms this conclusion. See Record, pp. 216, 223, 224, 353–358, 260, 261, 369; and note particularly Mr. Shedd's channel profiles, showing an unchanged depth of water in the pockets of the channel — where rolling or suspended material would be most likely to accumulate — all the time from 1835 to 1900. Note also the fact that, according to the Harbor and Land Commissioners, the total deposits on the undredged portions of the channel above the glacial drift, that is, the total deposits since the same first began to accumulate in the post-glacial age, amount to only about one foot. Sen. Doc. 303 of 1895, p. 8.

The foregoing considerations dispose, we submit, of the theory or opinion that the depth and width of the main channels of Boston harbor are in any manner dependent on the scour of the Charles River basin.

Let us assume, however, that these considerations are fallacious, that the harbor channels were created by tidal scour, and that tidal scour is necessary to maintain them. Let us give to these assumptions all the force that the United States commissioners of fifty years ago felt they deserved, and let us see what application they have to the present conditions of the problem.

The main ship channel of Boston harbor had originally a minimum depth of 16 feet and a minimum width of 100 feet at mean low water. Report of Chief of Engineers, U. S. A., for 1901, p. 152. Systematic work for the improvement of the harbor was begun by the United States government soon after the close of the labors of the United States commissioners in 1866 (*ibid.*, p. 1099); and when the project now under way is completed, the minimum cross-section of the channel at mean low water will be 1,200 by 35 feet, in-

stead of 100 by 16 ; or 42,000 square feet, as compared with 1,600. The harbor will have been converted from a natural into an artificial creation. Record, pp. 359, 360, 369.

Now, if, as the scour theory assumes, the conflicting forces of erosion and shoaling had reached an "equilibrium," so that the tidal scour from the interior reservoirs was just sufficient to maintain a clear water way 16 by 100 feet at its narrowest and shoalest point, of what value will this same scour be in keeping clear a channel with a minimum cross-section below mean low water twenty-six times as large? Clearly of little or none.

The dredge must evidently be relied on to do most of the work ; then why not all of it, letting us realize the obvious advantage of cutting off the last two feet of the ebb, and of a quieter condition of the water at the mouth of the river? The cost will be insignificant. The modern dredge is a vastly more effective machine than the apparatus in use thirty years ago ;* and Professor Peirce's estimate of $8,000 per annum was based on an estimated cost of 50 cents per cubic yard, — a price much higher than that now current for similar work. Mr. Stearns estimates the utmost annual expense for dredging at $3,000 to $4,000 (Joint Board, p. 31 ; H. & L., p. 505) ; and the total cost of removing all the shoaling caused by shifting materials between 1861 and 1892, as reported by the Harbor and Land Commission in Sen. Doc. 303 of 1895, p. 4, would, at 20 cents per cubic yard, amount to only $308,882, or less than $10,000 per annum. The cost of removing the *net* shoaling of the same period would be only $18,363, or less than $600 per annum. See also Blake, Record, pp. 223, 224.

The idea that a great and purely artificial harbor such as that of Boston can be substantially affected, either for good or ill, by anything that may be done in the insignificant basins of the Charles and Mystic, is on a par with the opinions held by the advocates of tidal scour concerning the natural advantages of this harbor for commerce. The State commissioners of 1852 considered that "Nature made Boston harbor one of the best in the world;" † the United States commissioners thought the harbor was "one of the safest and most commodious harbors in the world ;" ‡ Mr. Boschke said in 1869 that Boston harbor was "about the most perfect harbor ;" § and Professor Peirce thought, in 1871, that "the shipping of the future must be accommo-

* See Record, p. 361.
† Senate Doc. 45 of 1852, p. 23.
‡ City Doc. 12 of 1861, p. 47.
§ City Doc. 128 of 1869, p. 51.

dated in the basin of the Charles"! * The United States engineers of the middle of the last century were as much mistaken in regard to the commercial necessities of the future as they were about the physical history of the past.

This whole question may, it seems to us, be summed up in a sentence: Nature endowed this city with harbor channels good enough in ancient days, but totally inadequate to the needs of modern commerce; these channels were, in all probability, neither created nor maintained by the tides; but however this may be, they have been superseded by artificial channels, which must be maintained, as created, by the dredge;† and this condition permits us to realize the slight advantage to the harbor of a dam, and the inestimable advantage to the people of a water park above the dam, at no greater cost to the harbor than (at most) a small and occasional expenditure for dredging.

In the light of present information, it is unlikely that any shoaling will ever take place; but, if it does, a small expense for dredging will be the entire cost to the community — so far as the harbor goes — of this great improvement.

The cost of any dredging necessary, in the opinion of the United States War Department, to remove shoals that may accumulate in the new channel after its completion, might be charged to the annual expense of the basin without any fear that such a charge would ever amount to a substantial burden.

VII. — The Sanitary Questions.

The objections to the proposed improvement, based on the alleged unsanitary conditions that may follow the conversion of the Charles River basin into a permanent fresh-water reservoir, have no application to the present proposition; for, if this plan is carried out, the basin behind the dam can be made to contain either fresh or salt water, as may turn out to be most desirable, and the water, if salt, can be renewed as frequently as may be thought necessary. See *supra*, pp. 502, 503. We shall therefore not discuss these objections with the same detail with which we have argued the fundamental question of tidal scour; and we might indeed pass them entirely by, as not affecting the present proposition. In view, however, of the consideration which has been given to this branch of the case not only by the Joint

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* House Doc. 413 of 1871, p. 39.

† If alliteration may be permitted, it is the scow and not the scour upon which our harbor, under the purely artificial relations of the future, must rely.

Board and the Harbor and Land Commission but also at the hearings before this committee, and of the fact that some sort of a report from the committee upon these questions is expected, we will briefly outline our views as to the sanitary effect of a permanent fresh-water basin, and will then point out the inapplicability to the present proposition of any of the apprehensions as to the effect of such a dam as was proposed by the Joint Board.

A. — The Proposition for a Permanent Fresh-water Basin.

The petitioners contend that the transformation of the tidal portion of the river into a fresh-water, constant-level basin, substantially as proposed by the Joint Board, will be a distinct improvement, from a sanitary stand-point, over present conditions.

In support of this contention the petitioners point to the official decisions or opinions of the State Board of Health (see Joint Board, pp. 6–17, 23–32), the Metropolitan Park Commission (see Joint Board, and Record, pp. 25–34), the Board of Health for the city of Boston (Record, p. 371), the Massachusetts Association of Boards of Health (H. & L. App., xxxix), and other medical societies (*supra*, p. 499); to the individual opinions of State and city officials, such as Mr. Stearns, Dr. Walcott, Mr. Mills and Dr. Durgin; to the opinion of one hundred physicians* of high standing, who at one time or another have expressed the belief that such a

* Dr. John G. Blake.
Dr. Vincent Y. Bowditch.
Dr. John W. Farlow.
Dr. Paul Thorndike.
Dr. James R. Chadwick.
Dr. Arthur T. Cabot.
Dr. C. F. Folsom.
Dr. W. T. Councilman.
Dr. O. G. Cilley.
Dr. Conrad Wesselhoeft.
Dr. Elbridge G. Cutler.
Dr. Hall Curtis.
Dr. Morton Prince.
Dr. W. L. Burrage.
Dr. Edward P. Colby.
Dr. Wm. M. Conant.
Dr. Chas. S. Butler.
Dr. Jno. T. Bowen.
Dr. W. H. White.
Dr. Mary R. Mulliner.
Dr. Fred'k W. Halsey.
Dr. Thos. Waterman.
Dr. Geo. S. Whiteside.
Dr. Edward R. Williams.
Dr. M. L. Chambers.
Dr. Geo. F. Eames.
Dr. Edward M. Hartwell.
Dr. Edward De La Granja.
Dr. Robt. B. Greenough.
Dr. F. M. Johnson.
Dr. Edw. B. Kellogg.
Dr. Regn. H. Fitz.
Dr. Geo. F. Harding.
Dr. Robt. B. Dixon.
Dr. H. O. Marcy.
Dr. G. C. Smith.
Dr. Mary A. Smith.
Dr. J. B. Swift.
Dr. Myles Standish.
Dr. Jas. S. Stone.
Dr. Wm. R. May.
Dr. Mark W. Richardson.
Dr. Wm. L. Richardson.
Dr. W. E. Page.
Dr. Willard A. Putnam.
Dr. Calvin G. Page.
Dr. Jno. C. Munro.
Dr. Robt. M. Lawrence.
Dr. Fred'k I. Knight.
Dr. Geo. W. Kaan.
Dr. Chas. L. Kingsbury.
Dr. Elliott P. Joslin.
Dr. Fred'k L. Jack.
Dr. W. D. Hall.
Dr. Allen Greenwood.
Dr. Chas. M. Green.
Dr. D. Crosby Greene.
Dr. George H. Earl.
Dr. F. W. Draper.
Dr. Arthur L. Chute
Dr. George A. Craigin.
Dr. A. Coolidge, Jr.
Dr. Hugh Cabot.
Dr. E. A. Codman.
Dr. F. J. Cotton.
Dr. Edwd. C. Briggs.
Dr. Frederic M. Briggs.
Dr. Rufus L. Thurston.
Dr. Chas. W. Townsend.
Dr. Geo. C. Taplin.
Dr. Benj. Tenney.
Dr. Henry E. Spalding.
Dr. Malcolm Storer.
Dr. Grace Wolcott.
Dr. Frank A. Higgins.
Dr. John B. Brainerd.
Dr. Walter C. Bailey.
Dr. Geo. S. C. Badger.
Dr. John B. Blake.
Dr. John W. Cummin.
Dr. Hugh Williams.
Dr. J. Emmons Briggs.
Dr. Seabury W. Allen.
Dr. Jno. T. Bottomley.
Dr. Howard A. Lothrop.
Dr. Wm. Y. Allen.
Dr. Sumner Paine.
Dr. Arthur H. Nichols.
Dr. W. E. Paul.
Dr. Frank W. Page.
Dr. Frank J. Triggs.
Dr. Edward H. Bradford.
Dr. M. L. Chamberlain.
Dr. Ella L. Dexter.
Dr. Francis B. Harrington.
Dr. Chas. P. Putnam.
Dr. Chas. H. Porter.
Dr. Geo. J. Englemann.
Dr. John J. Thomas.
Dr. Oliver Wadsworth.

basin would be a sanitary improvement over present conditions; to the investigation made and conclusions reached by Mr. A. M. Mattice, engineer to the Cambridge Park Commissioners (see their annual report for 1894, Part II.; and H. & L., 706–808); to the report of the Boston sewer division for 1901–1902 (City Doc. 40 of 1902, pp. 192–226); to the investigations and reports of Messrs. Blake and Shedd (Record, pp. 195–209, 230–233, 256–270, 279–284, 361–369); and to the data collected for the committee by its own engineers.*

Our contentions in detail, having reference to the specific objections that have been suggested, are as follows: —

Temperature. — The presence of tide water in the Charles River basin, as it now exists, can have no appreciable effect upon the temperature of the neighboring districts.

Ground Water. — To maintain the river water at or about grade 8 will have no appreciable effect, one way or the other, upon the level of the ground water on either side of the basin.

That the ground water will not be materially lowered is shown by the history of the receiving basin of the Boston and Roxbury Mill Corporation; and there is no reason to apprehend that it will be raised. See Blake, Record, pp. 258, 259; Hering, *ibid.*, p. 444.

Direct House Sewage. — There is very little direct house sewage discharging into the river or its tributaries, and what there is should be removed without regard to the question of the dam. The discharge of sewage directly into the basin produces unpleasant and unwholesome conditions at the present time which should not be permitted to continue.

Plans have been made for the elimination of the Beacon Street house sewage at an estimated cost of $60,000; and this change should be carried out, whether the dam is built or not.

The cost of remedying these conditions is not chargeable to the dam, although the city of Boston might well be directed to connect these houses with its regular sewage works at a date not later than that estimated for the completion of the dam.

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* See also the opinions of Professor Sedgwick (H. & L., 597–644), Mr. E. D. Leavitt (H. & L., 655), Mr. A. F. Noyes (H. & L., pp. 815–853), and others, who testified before the Harbor and Land Commissioners in 1894.

It is also understood that a small amount of house sewage and factory waste may find its way, under present conditions, into Stony Brook, and thence through the Fens into the river. These buildings also should be connected, at once and mandatorily if necessary, with the city sewers; but still less than in the case of the Beacon Street houses should the cost be charged to the dam.

Stony Brook. — It is agreed that this, the only tributary of the Charles which is of any special importance to the question under consideration, must be carried in a covered channel, large enough at least to take all the foul or early storm flow of the water-shed, directly to the river.

This improvement, also, is one which must be made irrespective of the dam; and the estimated cost of it, $300,000, should not be charged to the latter.

After this conduit is built, dredging at its mouth will perhaps be necessary, whether a dam is built or not; as the experience of 1898 (Dorr, Record, pp. 78, 79; Putnam, Record, p. 116) shows that the tide is not able to carry off the mud brought down by the brook into the Fens and from there pumped into the river. This mud had to be taken out by dredging, and the same thing may have to be done from time to time after the dam is built.

Dredging seems also necessary, under present conditions, at the mouth of Muddy River. A. H. French, Record, p. 21.

While we think, for administrative reasons, that this work (as well as all other work within the basin) should be put in charge of the officials having control of the dam, and the cost thereof included in the annual cost for maintenance of the dam and basin, it is proper to point out that this particular item of expense, like the cost of the conduit itself, must be incurred any way, whether the dam is built or not, and should not be considered as an expense caused by the dam.

The Fens. — With the removal of the foul flow of Stony Brook, nothing will be required to make the condition of the water in the Fens wholesome and attractive but a better circulation; and this can best be obtained by pumping river water into the park, at an estimated cost of about $6,000 per annum. See Blake, Record, p. 207.

This again is an expense which must be met, whether we leave the river as it is or not, and should be charged to the Boston park department, not to the dam. So as to any dredging now necessary.

By means of the pump and an occasional slight lowering of the level of the basin the water in the Fens can be renewed as often as proves desirable; and the building of the dam will permit the use of fresh water, which is admittedly more desirable for park purposes than salt water.

Malaria. — There is no reason to apprehend the spread of this disease anywhere in this vicinity; * and the last place of all to expect it will be the neighborhood of a broad, wind-swept basin, the waters of which will be in a state of agitation too constant to encourage the breeding of mosquitoes, — without which the disease is not transmitted to human beings. Nobody ever finds mosquitoes around a basin or lake of this size which has no swampy margins. Compare Chestnut Hill Reservoir, Jamaica Pond, Mystic Lake, the Sudbury basins, etc.

Clean Water. — The water now brought in by the tide is not pure, and does not come directly from the sea. It consists in great part of water which has been flowing up and down for many tides, and contains a great deal of foul matter picked up in the harbor and along the wharves. See Mattice, pp. 35–38; Blake, Record, pp. 196, 200, 256, 257; seventh report of United States Commissioners, City Doc. 33 of 1864, p. 73.

The river water, on the other hand, as it flows over the dam at Watertown, while not sufficiently pure to be used as a public water supply, is, from a sanitary stand-point, substantially clean and wholesome (Record, pp. 89, 231, 232, 369); and when the changes now contemplated in the drainage of the Beacon Street houses and the Stony Brook valley are completed, and the high-level metropolitan sewer is built, there is every reason to expect a far clearer and more attractive water in the proposed basin than we find at the present time.

The petitioners contend that to exclude the tide water entirely from the basin will purify rather than pollute the water in it.

The Ebb Tide Guzzles. — The last run of the ebb tide scours the flats in gullies or guzzles, and erodes a considerable amount of mud, as may be seen any day at low tide (Record, pp. 221, 232, 233, and *supra*, p. 512, 513); and

* See testimony of Dr. Henry J. Barnes, who opposes the construction of a purely fresh-water basin, Record, pp. 295, 302, 303, 308.

the material thus lifted is dispersed through the basin by the incoming tide.

This cause of discoloration will be stopped if the dam is built.

The Flooding of Cellars. — This is a cause of much complaint at the present time, both in Boston and Cambridge, as the tide sometimes raises to grade 14 or 15, several feet above the cellar floors.

These annoying and unsanitary occurrences will of course be put an end to if the water in the river is not allowed to rise above grade 8.

The Overflow Sewage. — Some pollution of the basin is to be expected during storms, from those districts which are sewered on the "combined system," and there appears to be some conflict of opinion both as to the amount of sewage that will thus find its way into the basin and as to its effect upon the water.

We understand that the committee is making a thorough investigation into this branch of the inquiry, and we have the greatest confidence that the result will be to confirm the opinions held by Messrs. Walcott (Joint Board), Stearns (Joint Board and H. & L.), Mattice (pp. 16–28), Goodnough (Record, pp. 112, 113), Blake (Record, p. 204) and Shedd (Record, p. 365), that under no conceivable circumstances will there ever be any trouble from this source.

The construction of marginal sewers has been suggested, at an estimated cost of $590,000 for the Boston side of the river from the dam to the proposed new outlet for Stony Brook; but there is no reason for incurring this expense before its necessity is evident. Any unpleasant condition of the basin would arise slowly, and there would be ample time to renew the water by letting in the tide even with the type of dam proposed by the Joint Board; and, if the occasions on which this course must be resorted to become frequent, it will then be time enough to consider whether the storm flow of the sewers shall be discharged below the dam by means of marginal conduits. This is the worst that can possibly happen; but, if it does, the cost of the marginal sewers should not be considered as an argument against the proposed basin, for the cost of the dam, if built at Craigie bridge, will be practically nothing. *Supra*, p. 504.

The possible infusion of sewage is the only ground of objection to the proposed dam which seems to us to be worthy of serious consideration; and this objection applies only if

the dam is used to support a permanent and purely fresh-water basin. We have, however, been much impressed with the investigations and arguments of Messrs. Blake and Shedd, supporting, as they do, at every point the conclusions reached eight years ago by Mr. Stearns; and we believe that, if the committee will carefully consider the facts noted and opinions expressed by the independent public officials who have testified before this committee, — namely, Messrs. X. H. Goodnough, chief engineer to the State Board of Health (Record, pp. 89–113), W. M. Brown, chief engineer to the Metropolitan Water and Sewerage Commission (Record, pp. 119–127, 372, 373), G. C. Emerson (Record, pp. 131, 132), and particularly the exhaustive discussion of the subject in the current report of the superintendent of streets (City Doc. 40 of 1902, pp. 192–226), — they cannot fail to reach the conclusion that Mr. Stearns was substantially correct in his first impression of the matter, as set forth in the Report of the Joint Board and in his testimony before the Harbor and Land Commission in 1894.* When the high-level sewer of the metropolitan system is completed, in 1904 (Record, p. 15), it will be possible to prevent any of the first or foul part of the storm flow of the Boston sewers from reaching the river at all (City Doc. 40 of 1902); and under these conditions the sewage that will find its way into the basin will be too insignificant in quantity to have any appreciable effect upon the appearance or quality of the water.

If, however, this conclusion should prove to be a mistaken one, and if at any time in the future enough sewage should get into the basin to cause bad odors or other unwholesome conditions at certain seasons of the year, the foul storm flow — or the entire storm flow, if thought best — of Stony Brook and the littoral sewers can be carried below the dam by means of a marginal conduit; or, as explained below, if the petitioners' flexible type of dam is adopted, the basin can be temporarily converted into a tidal reservoir, and the construction of the marginal sewers postponed until it be determined whether the value to the community of a permanent fresh-water basin is worth the cost of these conduits.†

B. — The Present Proposition.

While maintaining that it will never be necessary, on sanitary grounds, to let salt water into the basin, and that at any and all times of any year, however dry, the river

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* See Joint Board, pp. 6–17, 23–32; H. & L., 426–597; and opinions of Mr. A. F. Noyes, H. & L., 815–853.

† These sewers need be of moderate dimensions only. W. M. Brown, Record, p. 120.

water will be more wholesome and agreeable than if the tide were let in, still, the petitioners believe, for the reasons explained *supra*, pp. 495, 502, and Record, pp. 286–291, that it is better, *ex majore cautela*, to furnish the dam with discharging sluices, large enough to empty and fill the basin in case of emergency in a single ebb and flow of the tide.

None of the objections to the plan of the Joint Board have any application to the project advocated by the petitioners in this case, which, as pointed out above (pp. 502–504), involves the construction of the dam in such a manner that the basin behind it can be operated with such frequent renewals, with such an admixture of fresh and salt water, and otherwise, as experience may indicate to be necessary or desirable for the health of the community.

The practicability and elasticity in operation of the type of structure now proposed has not been disputed by any one, and a few illustrations will serve to show how completely such a dam meets all the objections raised to the project of the Joint Board.

If, for instance, in a very dry summer the water should become offensive, the basin could be emptied to grade 2,* and refilled with salt water. This conversion could be so managed as to be accomplished in several weeks, several days or several tides, as might be thought desirable, or could be effected in the course of a single tide. Record, pp. 252–254, 265–270. A single renewal during the summer would probably be sufficient; if not, the water could be changed as frequently as desired. At the very worst, a change of water once in twenty-four hours, or on every other tide, during an exceptionally dry season, could be so managed as to keep the water at approximately grade 8 during that period of the day when the basin would be used by the multitude. There is no reason to apprehend any necessity for such extreme measures; but, even if they should be resorted to during a particularly dry period, the utility of the basin as a public recreation area would be but slightly impaired.

In like manner the dam could be so manipulated as to maintain a half-tide basin, emptied and refilled once in two or more tides, with a water level fluctuating between grades 8 and 5. Such a basin would be a vast improvement over present conditions, and could be so operated as to have the water practically at grade 8 during the hours of use. We see no reason to apprehend that this mode of operation will

* Or lower, if desired.

ever prove necessary, but the possibility may be worth taking into account.

Finally, we will call attention to the fact that Dr. Henry J. Barnes, the only professional man, except the experts retained, who appeared as a remonstrant at the hearings before this committee, confined his criticism to the permanent fresh-water basin, and said that he saw no objection to the type of dam proposed by the petitioners. Record, pp. 293, 308.

Another advantage, already noted (*supra*, p. 505), of the flexible type of dam proposed by the petitioners, is that it will postpone the necessity for the construction of marginal sewers in the improbable but theoretically possible contingency that enough sewage will in dry seasons of a dry year find its way into the basin to render the water obnoxious. Under these conditions, wholly unlikely to arise, but still in our judgment proper to consider and provide for, the basin can be operated during the dry periods of a dry year as a salt-water basin and during the rest of the year as a fresh-water basin, unless the community concludes that it is worth the cost of the marginal sewers to have the basin filled with fresh water throughout the year.

VIII. — Alternative Propositions.

1. *Dredging the Basin.* — This, to be effective in removing the sight and smell of the mud flats, must be carried below the run of the spring tides, or to a level 3 to 5 feet below mean low water, and should extend from West Boston bridge to Watertown. Dabney, Record, p. 327.

The cost of dredging would be prohibitory; * and none of the advantages to be secured by a permanent level basin — of either salt or fresh water — would be gained. Except the obliteration of the flats, all the other disadvantages of the present situation, foul water, fluctuating level, etc., would remain.

For these reasons, this scheme seems to us wholly inadmissible.

2. *A Half-tide Dam.* — The proposed dam could be so operated as to prevent the tide from ebbing below grade 5 (*supra*, p. 503); but no such half-tide dam as is in operation on the Thames at Richmond would solve the problem of the Charles. What is needed here, if the half-tide dam idea is to be carried out, is to prevent the ebb from receding below

* At least $2,000,000. See Mr. Blake's estimate, based on the soundings made by the committee. *Infra*, pp. 544, 545.

grade 5 and the flood from rising above grade 8. Such a mode of operation is perfectly feasible with the type of dam now proposed, and would secure as complete a renewal of the water in the basin twice each day as if no limit were set to the inflowing tide, besides meeting the requirements of the local problem much better than a dam of the Richmond type.

To build a dam on the Richmond plan, which could be used only as a half-tide dam, would be foolish, if all the benefits of a half-tide dam can be secured from a different type of structure, capable at the same time of being operated in other and perhaps more beneficial ways. If, therefore, the half-tide idea is to be considered at all, the type of dam proposed by the petitioners should be adopted; * although we do not believe that the basin would ever be operated in this manner.

Conclusion.

The foregoing argument is devoted rather to answering the objections which at various times have been raised by the opponents of a dam across the Charles River, than to a description of the benefits which will follow its construction. These benefits are almost self-evident, and have been so fully set forth in the statements to the committee by Messrs. Storrow (Record, pp. 152–188), Eliot (*ibid.*, p. 134), Byrne (*ibid.*, p. 136), Lawrence (*ibid.*, p. 137), Fitzgerald (*ibid.*, p. 139), Higginson (*ibid.*, p. 142), Shepard (*ibid.*, p. 144), Woods (*ibid.*, p. 145), DeMarco (*ibid.*, p. 147), Hubbard (*ibid.*, p. 148), Dr. Blake (*ibid.*, p. 149), P. M. Blake (*ibid.*, pp. 189–270), and Shedd (*ibid.*, pp. 270–284, 349–369), in the letters referred to *supra*, p. 500, in the report of the Joint Board, the report of Mr. Mattice, and in the recent letter of the Metropolitan Park Commissioners (Record, pp. 25–34), that any further argument to show the advantages of the proposed basin seems unnecessary. We will therefore close this paper with a simple enumeration of the chief benefits to be secured by the conversion of the Charles River below the Watertown dam into a fresh-water, constant-level basin, maintained at about grade 8 by a dam at Craigie bridge.

The effect of the proposed dam upon the depth and width of the main ship channel in the harbor below the Navy Yard will be slight, any way, and beneficial rather than injurious.

* As admitted by Mr. Dabney, Record, p. 329.

The effect upon the mouth of the river immediately below the dam and before the main ship channel is reached will be distinctly advantageous.

The effect upon navigation above the proposed dam will be beneficial, the advantage of a constant depth of water more than offsetting the inconvenience caused by the lock.

The exposure of the foul, malodorous and unsightly flats now visible in one part or another of the basin for several hours at every tide will be prevented.

The water in the basin will be pure, clear and fresh, instead of foul, muddy and salt.

The flooding of cellars in Boston and Cambridge will no longer be possible.

The reclamation of the marshes along the upper reaches of the river will be easier and much less costly.

The cost of embankments along the sides of the basin still unprovided therewith will be much less, and beaches can be substituted for stone walls in many places.

Better planting, that is, a greater variety and more vigorous growth of trees and shrubs, in the parkways bordering the river can be secured.

Splendid facilities, not now existing, will be furnished for boating, sailing and skating.

A great and much-needed breathing space or pleasure area will be provided for the dense populations of the city proper and East Cambridge.

The health, recreation and happiness of several hundred thousand people will be promoted.

The beauty and attractiveness of the city as a residential resort will be enhanced.

The conversion of what is now practically a waste area is necessary to the completion of the Boston and Metropolitan park systems, which together have cost over $27,000,000, and which, when supplemented and connected by the proposed water park, will constitute the most extensive, most central and most beautiful parks to be found in any great city in the world.

Of this expenditure, nearly $3,000,000 has been for improvements on the river, the utility of which will be largely if not wholly lost if the dam is not built.

The first cost of this final and crowning feature of our public parks will be little or nothing, and the annual cost of maintenance inconsiderable.

The city of Boston, with the surrounding towns and cities, — greater Boston, as it is called, — forms essentially

one community; but it is not a manufacturing centre, it is distinctly a commercial and residential city. The harbor, upon which its commercial interests depend, has been handed over to the dredge and scow for improvement, for preservation, in fact for re-creation; and no thought need be given to the function or value of the Charles River basin in the creation or maintenance of the natural and original channels.

That basin lies in the geographical middle of the metropolitan district, with its 1,500,000 inhabitants; and the territory immediately adjacent to it is occupied by several hundred thousand people, a large part of whom are crowded with unwholesome density into tenement-houses, in districts traversed with narrower streets than are to be found in any other large city in this country, and practically devoid of open spaces available for health and recreation. Large sums of money are expended from time to time in redeeming a half acre or so from private occupation; but the cost of rendering the tenement-house districts desirable or even fit for healthful habitation by expropriating large areas of land for park purposes is prohibitory.

Here, however, close at hand, we have an area of nearly 1,000 acres, easily accessible from all the crowded sections of the metropolitan district; which is now of practically no value, commercial or otherwise, to the community; which, in its present foul and unsanitary condition, is a source of constantly increasing annoyance during a large part of the time; and which can be converted, as it happens, at a ridiculously small expense, into the very thing which is most required to meet the residential conditions of the community, — a water park, with public embankments, landing-places, boating and all the other health-giving means of recreation only to be enjoyed in such a park.

The great benefits that will be secured by converting this now useless, and sometimes worse than useless, basin into a public park, can be imagined when we consider the popular use now made of the Charlesbank and of Marine Park, and the immense utility to the great cities of London, Paris, Philadelphia, and Hamburg of the fresh-water streams and basins which those cities have had the intelligence to improve or create. In none of these cities has the improvement been followed by any unsanitary conditions; and we may also refer to the more or less artificial basins of the Upper Mystic Pond and Leverett Pond, as proof that in this particular neighborhood the transformation of tidal mud flats into fresh-water parks is from every point of view desirable.

Here in Boston a greater opportunity exists, having reference to situation, area and cost, than that presented by the Thames, the Alster or the Seine in their natural condition. No other city in the world would let such an opportunity pass, in deference to fears of unsanitary results not warranted by the facts of the case, and admitted to be unfounded if a dam is built which can flow the basin with salt water whenever needed; or to theories of tidal forces, promulgated sixty-five years ago, and now shown to have been based on inaccurate information and on erroneous geological assumptions; or to the relatively light financial burden involved in the project; or to the objections raised by private interests.

The community is alive to its opportunity, and has long been determined to carry out this great improvement as soon as the State Legislature and the United States government consent.

We are confident that the result of this investigation will be to sweep away the last vestige of opposition based on scientific or public grounds, leaving only the private interests to contend with; and that the great water park, first suggested forty-three years ago, will become an actuality within the short time required to build the dam.

Respectfully submitted by

NATHAN MATTHEWS, Jr.,
WILLIAM S. YOUNGMAN,
Counsel for Henry L. Higginson and Others.

Boston, November, 1902.

APPENDIX.

LETTER FROM PROF. WM. H. NILES.

BOSTON, MASS., Dec. 15, 1902.

Hon. NATHAN MATTHEWS, Jr.

DEAR SIR: — I have examined the geological literature, to ascertain when engineers first could have had access to a clear presentation of the now accepted interpretation of the characteristic features of Boston harbor. Dr. Edward Hitchcock's final report upon the geology of Massachusetts, which was relied on by some of the United States Commissioners on Boston Harbor,* was published in the year 1841. The first interpretation of some of the physical features of this country as having originated under the influence of ancient glaciers was first set forth by Agassiz, who set sail for America in September, 1846. Hitchcock, therefore, had had no opportunity of knowing, at the time of the publication of his work, the explanation subsequently given by Agassiz. Notwithstanding this, Professor Hitchcock does not say in his report that what he called the diluvial agencies formed the harbor, but that one was naturally led to inquire whether they might possibly have been the origin. His paragraph upon this subject is closed with these words: "And yet, we are staggered in our belief when we reflect on the immense period of time requisite for such a work, and doubt whether other geological facts do not indicate a later commencement to the present order of things on the globe." It seems from this quotation that Professor Hitchcock, at the time of writing his final report, anticipated that there might be a more satisfactory explanation of the features of Boston harbor. That explanation has been furnished by the discoveries of more modern science.

Although publications upon this subject extended over a number of years, we cannot say that the origin of these features, as we now understand it, was explained and available to engineers before 1884. In connection with this statement it should be borne in mind that the discovery by Louis Agassiz in 1846, that the striations and polished surfaces of certain rock surfaces in this country were of glacial origin, did not reveal the origin of Boston harbor as now understood. The discovery of Agassiz awakened among geologists a long series of investigations, which are still actively pursued. It was impossible to fully understand the causes by which the features of Boston harbor were produced, until the nature of the hills constituting its islands was satisfactorily determined. These hills are now known to be drumlins. The earliest statement that the drumlins of any country were of glacial origin seems to have been made with reference to certain hills in Ireland in 1864. It was some time before the rounded hills of Boston and vicinity were recognized by their form as belonging to the class of drumlins; even then, their origin was not completely explained. The

* See second report of the United States Commissioners, City Doc. 97 of 1860, p. 21.

question whether they had been built up or had been eroded out of a once more extensive formation, and reduced to their present outlines, was one of primary importance. Prof. C. H. Hitchcock, Mr. Warren Upham, Prof. W. M. Davis and others were participants in this discussion. In 1884 Professor Davis published an article in the "American Journal of Science," under the title of the "Distribution and Origin of Drumlins." This article was republished in a paper known as "Science" during that same year. This article, I believe, was the first clear presentation of the now accepted origin of drumlins. We may therefore conclude that, until that article was published, engineers had no opportunity for an understanding of the origin of Boston harbor in the light of modern geology. It was claimed by Professor Davis, and it is now believed by geologists generally, that the drumlin hills constituting the islands of Boston harbor are composed of material of glacial origin, and that the ice of the glacial epoch placed them in their present positions.

There are satisfactory evidences that in glacial days the land of this region stood higher relative to sea level than it does at the present time. There are like evidences that the shore of the sea at that time was farther to the eastward than it now is. It was upon the recession of the glaciers and the subsidence of the land that marine waters were permitted to come in and occupy the lower portions. It was in this general way that Boston harbor originated.

At your request I take into consideration the address given by Maj. Charles W. Raymond, U. S. A., on Boston harbor, on the 8th of January, 1885. I have already called attention to the fact that the geological origin of Boston harbor, as now understood, was not published and made available for engineers before 1884. We should certainly excuse Major Raymond if he was not aware of the explanations which had been so recently given of the islands in the harbor. In his address we read the following sentence: "Out of the drift deposits in this great structural valley the harbor of Boston was formed by the erosive action of the sea, assisted by the action of the fresh water running down from the land." It is now known that the drift deposits to which he refers did not fill the great structural valley, and it is now shown that the islands are not mere remnants, left after an excavation of generally distributed material. There is no doubt that the glacial deposits have been somewhat modified by recent action, but not to the extent of determining the general characteristics of the upper harbor. In the region of which Major Raymond writes as the lower harbor the action of the sea has undoubtedly produced more important changes. I do not understand, however, that these are to be included in the present inquiry.

It is also to be noted that Major Raymond does not clearly discriminate between the part nature is taking in our day and the greater activity which prevailed before our advent here. We may believe that the deeper portions of the harbor which constitute what we call the ship channel were formed through the greater activity of forces quite a time before our historic period. We need have no doubt that the combined action of tides, currents, streams, etc., have caused very fine material to be deposited in said channel; but we are aware that the amount of this accumulation over the glacial drift is relatively small.

This statement will apply equally well to the views entertained by eminent engineers of an earlier time, who based their arguments upon the supposition that the harbor and its channels had been formed and are maintained by agencies acting with no greater energy than they do to-day.

WM. H. NILES.

Extracts from Prof. N. S. Shaler's chapter on the "Geology of Boston and its Environs," in Winsor's "Memorial History of Boston," pp. 1–8: —

During the last glacial period, and perhaps frequently in the recurrent ice times, of which we find traces in the record of the rocks, the ice sheet for long periods overtopped the highest of our existing hills, and ground away the rock surface of the country as it crept onward to the sea. During the first stages of the last ice period this ice sheet was certainly over two thousand feet thick in eastern Massachusetts, and its front lay in the sea at least fifty miles to the east of Boston. . . .

When the last ice sheet melted away, it left on the surface it had worn a layer of rubbish often a hundred feet or more in depth. As its retreat was not a rout, but was made in a measured way, it often built long, irregular walls of waste along the lines where its march was delayed. When the ice wall left the present shore line, the land was depressed beneath the sea to a depth varying from about thirty feet along Long Island Sound to three or four hundred feet on the coast of Maine. The land slowly and by degrees recovered its position; but, as it rose, the sea for a time invaded the shore, washing over with its tides and waves the rubbish left by the ice sheet, stripping the low hills and heaping the waste into the valleys. . . .

Although the general features of the topography of this district are determined by the disposition of the hard underlying rocks, the detail of all the surface is chiefly made by the position of the drift or glacial waste left here at the end of the last ice time, but much sorted and rearranged by water action. . . .

After the ice had lain for an unknown period over this region, climatal changes caused it to shrink away slowly and by stages, until it disappeared altogether. As it disappeared it left a very deep mass of waste, which was distributed in an irregular way over the surface, at some places much deeper than at others. At many points this depth exceeded one hundred feet. As the surface of the land lay over one hundred feet below the present level in the district of Massachusetts Bay when the sea began to leave the shore, the sea had free access to this incoherent mass of débris, and began rapidly to wash away. We can still see a part of this work of destruction of the glacial beds in the marine erosion going on about the islands and headlands in the harbor and bay. The same sort of work went on about the glacial beds, at the height of one hundred feet or more above the present tide line. During this period of re-elevation, the greater part of the drift deposits of the region about Boston was worked over by the water. Where the gravel happened to lie upon a ridge of rock that formed, as it were, a pedestal for it, it generally remained as an island above the surface of the water. As the land seems to have risen pretty rapidly when the ice burden was taken off, — probably on account of this very relief from its load, — the sea did not have time to sweep away the whole of these islands of glacial waste. Many of them survive in the form of low, symmetrical, bow-shaped hills. Parker's Hill, Corey's Hill, Aspinwall and other hills on the south side of Charles River, Powderhorn and other hills in Chelsea and Winthrop, are conspicuously beautiful specimens of this structure. Of this nature were also the three hills that occupied the peninsula of Boston, known as Sentry or Beacon, Fort and Copp's hills. Whenever an open cut is driven through these hills, we find in the centre a solid mass of pebbles and clay, all confusedly inter-

mingled, without any distinct trace of bedding. This mass, termed by geologists *till*, or boulder clay, is the waste of the glacier, lying just where it dropped when the ice in which it was bedded ceased to move, and melted on the ground where it lay. . . .

With the cessation of the disturbances of the glacial period and at the beginning of the present geological conditions, the last of the constructive changes of this coast began. Hitherto mechanical forces alone had done their work on the geography of the region; henceforward, to the present day, organic life, driven away from the shore and land by the glacial period, again takes a share in the constructive work. This is still going on about us. The larger part of it is done by the littoral sea weeds and the swamp grasses. Along the estuaries of the Saugus, Mystic, Charles and Neponset rivers there are some thousands of acres of lands which have been recovered from the sea by these plants. The operation is in general as follows: The mud brought down by these streams, consisting in part of clay and in part of decomposed vegetable matter, derived from land and water plants, coats the sandy bottoms or under-water terraces. In this mud, even at considerable depths, eel grass and some sea weeds take root, and their stems make a dense jungle. In this grass more mud is gathered, and kept from the scouring action of the tide by being bound together by the roots and cemented by the organic matter. This mass slowly rises until it is bare at low tide. Then our marsh grasses creep in, and in their interlacing foliage the waste brought in by the tide is retained, and helps to raise the level of the swamp higher. The streams from the land bring out a certain amount of mud, which at high tide is spread in a thin sheet over the surface of the low plain. Some devious channels are kept open by the strong scouring action of the tide, but the swamp rapidly gains a level but little lower than high tide. Except when there is some chance deposit of mud or sand from the bluffs along its edges, these swamps are never lifted above high-tide mark, for the forces that build them work only below that level. Their effect upon the harbor of Boston has been disadvantageous. They have diminished the area of storage for the tide water above the town, and thereby enfeebled the scouring power of the tidal currents. Except at the very highest tides, the Charles, Mystic and Neponset rivers now pour their mud directly into the harbor, instead of unloading it upon the flats where these marshes have grown up. There are other forces at work to diminish the depth of water in the harbor. The score or more of islands that diversify its surface are all sources of waste, which the waves tend to scatter over the floor. For the first two hundred years after the settlement the erosion of these islands was not prevented by sea walls, and in this time the channels were doubtless much shoaled by river waste. Just after the glacial period these channels were very deep. Borings made in the investigations for the new sewerage system showed that the channel at the mouth of the Neponset had been over one hundred feet deeper than at present, — the filling being the rearranged glacial drift brought there by just such processes as have recently shoaled the channels of the harbor.

The depth of this port has also been affected by the drifting in of sands along the shores contiguous to the north-east and south-east. When the sea surges along these shores, it drives a great deal of waste towards the harbor. A fortunate combination of geographical accidents has served to keep the harbor from utter destruction from this action. On the north side, whence comes the greater part of this drifting material, several pocket-like beaches have been formed, which

catch the moving sands and pebbles in their pouches, and stop their further movement. But for these protections — at Marblehead Neck, Lynn and Chelsea on the north, and Nantasket on the south — the inner harbor would hardly exist, since these lodgments contain enough waste to close it entirely.

See also Professor Shaler's elaborate article on the "Geological History of Harbors," in the thirteenth annual report of the United States Geological Survey for 1891–92, Part II., pp. 99–209, particularly pp. 164, 207.

MR. BLAKE'S ESTIMATE OF THE COST OF DREDGING THE BASIN, AS PROPOSED BY SOME OF THE REMONSTRANTS.

NEWTONVILLE, MASS., Dec. 26, 1902.

HON. NATHAN MATTHEWS, JR., *Counsel for Henry L. Higginson and Others, Boston, Mass.*

DEAR SIR: — I send you herein the information you have requested me to obtain concerning the dredging and walling of the Charles River basin, and to accompany this information I send you advance sheets of the survey of the basin below the Cambridge bridge, as prepared under the direction of the special committee.

Your inquiry was as to, first, the dredging of the basin so as to give a minimum depth therein at mean low water of 5 feet; second, as to the cost of constructing suitable retaining walls on the banks of the basin at and over such sections as could be best finished and protected by such walls.

The enclosed map shows by a green tint those areas of the present bottom of the basin which must be dredged if a minimum depth of 5 feet below mean low water is to be obtained. The portion tinted in red shows the areas of the present basin in which a depth of water of 10 feet or more below mean low water now exists. The upper end of the basin shown on this map terminates at the Cambridge–River Street bridge; the map of the portion of the river basin above this bridge is not submitted in final form, but the estimates made below may be taken as reasonably close for those portions of the suggested improvements above Cambridge–River Street.

The area to be dredged below Cambridge–River Street bridge, if a depth of 5 feet below mean low water is to be provided, is 234.4 acres.

The quantity of material to be dredged from this area is 1,711,316 cubic yards, which, at 28 cents per cubic yard for dredging and depositing by hydraulic or other process, would cost $479,168.48.

The area to be dredged above the Cambridge–River Street bridge will be 148.8 acres, which, at the same price, would cost $537,777.80, the excess over the previous estimate being due to the much greater average depth of material to be dredged over the smaller area.

The sum of these two items is $1,016,946.28.

The price per cubic yard is probably sufficient to pay not only for the dredging from the basin bottom, but the depositing of the dredged material along shore and behind the retaining walls.

If rock excavation or other hard material is to be removed, the price per cubic yard would be very largely increased; but it is believed that most of the material between Craigie bridge and the dam at Watertown is of a kind which would permit of the safe use of the price per cubic yard named above.

As to the length of retaining wall to be constructed, it is not possible to judge fairly without first developing by careful study, the best plan of improvement of the shores. The total lengths of unwalled shore line are now, for the south side, below Cambridge–River Street bridge, 4,600 feet; south side, above Cambridge–River Street bridge, 24,300 feet; north side, below Cambridge–River Street bridge, excluding 1,000 feet at "Captain's Island," 5,700 feet; north side above Cambridge–River Street bridge, 24,300 feet; the upper terminal point in each case being about 500 feet below the dam at Watertown.

If the retaining wall is to have its foundation at the depth of the dredging, or 5 feet below mean low water, and the top of its capstones is to be fixed at elevation 14 feet above mean low water, the total height of wall would be 19 feet, the thickness at base should be 9 feet, the thickness at top may be 3½ feet, making the cross-section 119 square feet and the quantity of masonry about 4½ cubic feet per lineal foot of wall.

Such a retaining wall, if constructed in considerable quantity of heavy split rubble with split quarry stones for its upper half, and split capstones, would probably cost $35 per lineal foot, finished. If a piling foundation should be required, $3 per lineal foot should be added to this price, making the cost for such retaining wall $38 per lineal foot.

Using the price of $35 per lineal foot, the cost of the wall on the south side below Cambridge–River Street bridge would be $161,000; south side, above Cambridge–River Street bridge, $850,500: north side below Cambridge–River Street bridge, $199,500; north side above Cambridge–River Street bridge, $850,500; making total cost of retaining walls, without pile foundations, $2,061,500.

Assuming that one-half of this walling only is required, and that one-half of this portion would require a piling foundation, the cost of the retaining walls then would be $1,119,100. Adding to this latter sum the cost of dredging, $1,016,946, the total cost of improving the basin would be $2,136,046.

Yours truly,

PERCY M. BLAKE.

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